International Journal of Mathematical Archive-9(6), 2018, 113-118
Available online through www.ijma.info ISSN 2229 – 5046

RADIATION HEAT SOURCE AND CHEMICAL REACTION WITH SPECIAL EFFECTS OF ACCUMULATION ON MHD FLOW PAST A VERTICAL PLATE

KRANTHIKUMAR KOTHA[1]
J. N. T. U. Kakinada, India.

Dr. CH. BABY RANI*[2]
VR Siddhartha Engineering College, Vijayawada, India.

Dr. A. V. PAPARAO[3]
Jntuk University Of Engineering, Vizianagaram, India.

(Received On: 28-05-18; Revised & Accepted On: 19-06-18)

ABSTRACT

The present study has been analyze the radiation heat source and chemical reaction with special effects of accumulation on mhd flow past a vertical with a source of heat on natural convective MHD flow with mass transfer over an electrically conducting incompressible dense fluid a vertical plate by homogeneous barrage high temperature. The governing boundary layer equations of the flow that transform into non dimensional form and solved by an efficient finite difference scheme.

Key words: *Chemical reaction, finite difference method, free convection, heat generation/absorption, radiation.*

AMS subject classification: *80M20, 76R10.*

1. INTRODUCTION

MHD flow with heat and mass transfer has been a subject of interest of many researchers because of its varied applications in science and technology. Such phenomenon is observed in buoyancy induced motions in the atmosphere, water bodies,quasi -solid bodies such as earth, etc. An important class of two dimensional time-dependant flow problem dealing with the response of boundary layer to external unsteady fluctuations of the free stream velocity about a mean value attracted the attention of many researchers. In natural processes and industrial applications many transportation processes exist where transfer of heat and mass takes place simultaneously as a result of the thermal diffusion and diffusion of chemical species. There are many transport processes that are governed by the combined action of buoyancy forces due to both thermal and mass diffusion in the presence of chemical reaction. These processes are observed in the nuclear reactor safety and combustion systems, solar collectors, metallurgical and chemical engineering

MHD is concerned with the study of the interaction of magnetic fields and electrically conducting fluids in motion. There are numerous examples of applications of MHD principles including MHD generators, MHD pumps and MHD flow meters etc. MHD principles find its applications in Medicine and Biology also. Radiative convective flows are encountered in countless industrial and environment processes like heating and cooling chambers, evaporation from large open water reservoirs, astrophysical flows and solar power technology. Due to importance of the above physical aspects, several authors have carried out model studies on the problems of free convective flows of incompressible viscous fluid under different flow geometries taking into account of the thermal radiation.

Corresponding Author: Dr. Ch. Baby Rani*[2]
VR Siddhartha Engineering College, Vijayawada, India.

2. REVIEW LITERATURE

1. M. A. Hossain, K. Khanafer, and K. Vafai,[2001] The effect of radiation on free convection flow of fluid with variable viscosity from a porous vertical plate," International Journal of Thermal Sciences, vol. 40, no. 2, pp. 115–124,
2. R.Muthcumaraswamy.M.Muralidharan [2005], Thermal radiation on linearly accelerated vertical plate with variable temperature ,heat and mass transfer
3. seddeek M.A.[2005] finite element method for effects of chemical reaction, variable viscosity, thermophoresis and heat generation/absorption on a boundary –layer hydromagnetic flow with heat and mass transfer over a heat surface.
4. G.S.Seth,G.K.Mahatoo,S.Sarkar,[2013]: Effects of hall current and rotation on MHD natural convection flow past an impulsively moving vertical plate with ramped temperature in the presence of thermal diffusion with heat absorption,
5. takhar H.S.Chamkha A.J., and nath G., [2000] flow and mass transfer on a stretching sheet with a magnetic. Field and chemically reactive species.
6. Ambethkar .V.[2009]: Numerical solution of heat and mass transfer effects of an unsteady MHD free convective flow past an infinite vertical plate with constant suction and heat source and sink.
7. A. V. Kuznetsov, [1996.]Analytical investigation of the fluid flow in the interface region between a porous medium and a clear fluid in channels partially filled with a porous medium. Appl. Sci. Res., 56, 53–67,

3. MATHEMATICAL ANALYSIS

We now consider an unsteady radiative MHD free convective flow of an incompressible viscous and electrically conducting heat absorbing fluid past vertical porous plate in its own place with temporary ramped temperature in presence of a magnetic field of uniform strength applied normal to the plate directed into the fluid region.

Our investigation is restricted to the following assumptions:

i) All the fluid properties are considered constants except the influence of the variation in density in the buoyancy force term.
ii) The magnetic Reynolds number is so small for that the induced magnetic field can be neglected in comparison to the applied magnetic field.
iii) The plate is electrically non -conducting.
iv) The radiation heat flux in the direction of the plate velocity is considered negligible in comparison to that in the normal direction.

Mathematical analysis of a two-dimensional, unsteady, natural convection flow of a MHD optically thick incompressible fluid past a vertical plate with uniform surface temperature and concentration with thermal radiation, chemical reaction and heat generation is considered. The x -axis is taken along the plate surface and y-axis along the perpendicular direction to the x axis

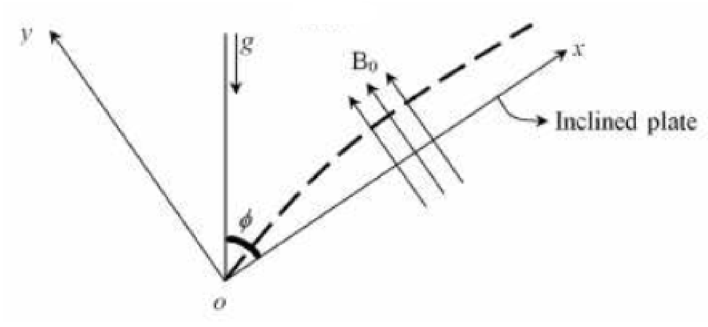

Figure 1: Coordinate System with Physical Model

(as shown in Fig.1). Initially, the plate surface and the fluid are at the same temperature and concentration.

It is assumed that the fluid considered is a gray absorbing/emitting, but non-diverging medium. An approximation by Rosseland is applied in the energy equation for the heat flux due to radiation, the plate surface and the surrounding fluid which is at rest are at the same temperature T'_∞ and concentration C'_∞Subsequently when time $t' > 0$, the temperature of the plate surface is suddenly raised to $T'_W$and the concentration of the surface near the plate is also raised to Cw and both are kept at the same level.

The radiation due to heat flux in the {x} direction is considered minimal in comparison with y direction. The governing equations of continuity, momentum and energy for natural convection flows under the Boussinesq's approximation can be shown as follows

Continuity equation:

$$\frac{\partial v}{\partial y} = 0 \tag{1}$$

Momentum equation:

$$\frac{\partial u}{\partial t} + \vartheta\frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + g\beta(T - T'_\infty) + g\beta(C - C'_w) + \frac{\sigma B_0^2}{\rho}\, u + \frac{V}{k}\, u - \frac{\partial P}{\partial x} \tag{2}$$

Energy equation:

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 u}{\partial y^2} + \frac{Q_0}{\rho c_p} g\beta(T - T'_\infty) + + \frac{1}{\rho c_p}\frac{\partial q_r}{\partial y} \tag{3}$$

Concentration equation:

$$\frac{\partial C}{\partial t} + v\frac{\partial c}{\partial y} = Dm\frac{\partial^2 C}{\partial y^2} + \frac{D_m K_T}{T_m}\frac{\partial^2 T}{\partial y^2} - K_r(C - C'_\infty) \tag{4}$$

The boundary conditions are

U=0 t=0 c=0 at y=0 (5)

U=0, T =T_1, C =C_1 y=h (6)

The radiative term $\frac{\partial c}{\partial y}$ in the energy equation is simplified by using Rosseland

$$q_r = \frac{4\sigma}{3k_r}\frac{\partial T^4}{\partial y} \tag{7}$$

Then equation (7) can be expanding T^4 into the taylor series T'_∞ which after be glecting higher order terms take the form

$$T^4 \cong 4T'^3_\infty T - 3T'^4_\infty \tag{8}$$

$$q_r = -\frac{16\sigma T'_\infty}{3k_r} \tag{9}$$

Substituting (8) and (9), into 3 we have

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \frac{K_0}{\rho C_P}\frac{\partial}{\partial y}(K(T)\frac{\partial T}{\partial t}) + \frac{16\sigma s}{3\rho C_{PKe}} T_\infty^3 \frac{\partial^2 T}{\partial y^2} \tag{10}$$

$v_0 > 0$ is the suction parameter and $v_0 < 0$ is the injection parameter. on introduction the following non-dimensional variables

$$U = \frac{u}{U_0},\ y = \frac{y}{H},\ t = \frac{tU_0}{H},\ \theta = \frac{T - T_\infty}{T_w - T_\infty},\ \varphi = \frac{C - C_\infty}{C_w - C_\infty},\ P_r = \frac{\rho U_0 C_\rho}{K_0},\ G_r = \frac{g\beta H(T - T_\infty)}{U_0^2}$$

$$G_c = \frac{g\beta H(C - C_\infty)}{U_0^2},\ M = \frac{\sigma B_0^2 H}{\rho U_0^2},\ R = \frac{4\sigma T_\infty^3}{KK_e},\ Sc = \frac{U_0}{D}$$

Where U is the mean flow velocity, into the equation (2),(3) and (4) with (1) identically satisfied. Numerical Soluytion Procedure:

The set of couple nonlinear governing differential equation (12)-(14) together with initial and boundary conditions are solved numerically by using the implicit finite difference technique of crank –Nicilson type. the finite difference approximatations equiv:

1. To prove the efficacy of our numerical results, the present results for the steady-state flow at X = 1.0 are compared with the solutions available in the open literature and are agreeing well with that.
2. Velocity, temperature, and concentration profiles for various values of Pr, Sc and N, chemical reaction parameter λ, heat generation parameter Δ, magnetic field parameter M and radiation parameter (Rd) .
3. It is observed from Fig. 2(a) that the thickness of momentum boundary layer increases for the fluids with Pr = 0.71 and decreases for Pr = 6.7. As the values of Sc increases, the concentration and velocity decreases.
4. An increment given to the buoyancy ratio parameter N leads the velocity to increase. The temperature reduces for all the values of N, shows the effect of the chemical reaction parameter λ on the velocity profiles. Due to the chemical reaction the considerable decrement in the velocity profiles is observed.
5. The heat source parameterΔ increases the profiles of velocity , depicts that the boosted magnetic field, and radiation generates reverse force to the flow is called Lorentz force. This force reduces the thickness of the velocity boundary layer.
6. We notice that the temperature decreases with increasing values of Pr. It is justified due to the fact that thermal conductivity of fluid decreases with increasing Pr and hence decreases the thermal boundary layer thickness and the temperature profiles. As the Schmidt number increases, the temperature increases. As we move away from the surface of the plate, the temperature decreases for all the values of the buoyancy ratio parameter N.

4. CONCLUSIONS

1. The velocity and temperature is more for smaller values of Pr, Sc, M, λ and Rd, but higher values of N and Sc and Δ. The local skin-friction decreases with the increasing values of Pr, Sc, M, λ and Rd but increases for N
2. Concentration increases with an increase in Pr, M, Rd and a decrease in Sc and N
3. The momentum boundary layer thickness reduces with the increase in Sc. The local Nusselt number reduces with the increasing values of Pr, Sc, M, Rd, Δ, λ but increase for N
4. The local Sherwood number decreases with the increasing values of Pr, Δ, M and Rd but increases fo r Sc, N and λ

REFERENCES

1. A. S.Gupta, I.Pop, V. M. Soundalgekar, Free convection effects on the flow past an accelerated vertical plate in an incompressible dissipative fluid, Rev. Roum.Science and Technology, Mecanical. Aplications, (1979), 24, 561 - 568.
2. N. G. Kaufoussias, A. A. Raptis, Mass transfer and free convection effects on the flow past an accelerated vertical infinite plate with variable suction or injection, Rev. Roum. Science and Technology, Mecanical Aplications, (1981), 26, 11 - 22.
3. P. L. Chambre, J. D. Young, On the diffusion of a chemically reactive species in laminar boundary layer flow, Physics of Fluids, (1958), 1, 48 - 54.
4. V. M. Soundalgekar, N. S. Birajdar, V. K. Darwhekar, Mass transfer effects on the flow past an impulsively started infinite vertical plate with variable temperature or constant heat flux, Astrophysics and Space Science (1984), 100, 159 - 164.
5. E. M. A Elbashbeshy, Heat and mass transfer along a vertical plate with variable surface tension and concentration in the presence of the magnetic field, International Journal of Engineering and Science, (1997), 35, 515 - 522.
6. H. S. Takhar, S. Roy, G. Nath, Unsteady free convection flow over an infinite vertical porous plate due to the combined effects of thermal and mass diffusion, magnetic field and Hall currents, Heat Mass Transfer, (2003), 39, 825 - 834.
7. P. Chandran, N. C. Sacheti, A. K. Singh, Natural convection near a vertical plate with ramped wall temperature, Heat and Mass Transfer, (2005), 41(5), 459 - 464.
8. R. Muthucumaraswamy, M. Muralidharan, Thermal radiation on linearly accelerated vertical plate with variable temperature and uniform mass flux, International journal of ScIence and Technology, (2010), 3 (4), 398 - 401.
9. R. R. Kairi, P. V. S. N. Murthy, Effect of double dispersion on mixed convection heat and mass transfer in a non-Newtonian fluid-saturated non-Darcy porous medium, Journal of Porous Media, (2010), 13 749 - 757.
10. A. J. Chamkha, A. M. Aly, M. A. Mansour, Unsteady natural convective power-law fluid flow past a vertical plate embedded in a non-Darcian porous medium in the presence of a homogeneous chemical reaction, Nonlinear Analysis Modelling Control, (2010), 15 (2), 139 - 154.
11. J. A. Rao, S. Sivaiah, R. S. Raju, Chemical reaction effects on an unsteady MHD free convection fluid flow past a semiinfinite vertical plate embedded in a porous medium with heat absorption, Journal of Applied Fluid Mechanics, (2012), 5 (3), 63 - 70.
12. U. S. Rajput, S. Kumar, Radiation effects on MHD flow past an impulsively started vertical plate with variable heat and mass transfer, International journal of Appied Mathematics and Mechanics, (2012), 8 (1), 66 - 85.
13. R. Sivaraj, B. Rushi Kumar, Viscoelastic fluid flow over a moving vertical plate and flat plate with variable electric conductivity, International Journal of Heat and Mass Transfer, (2013), 61, 119 - 128.
14. G. S. Seth, G. K. Mahatoo, S. Sarkar, Effects of Hall current and rotation on MHD natural convection flow past an impulsively moving vertical plate with ramped temperature in the presence of thermal diffusion with heat absorption, International Journal of Energy and Technology, (2013), 5, 1 - 1.
15. T. Poornima, N. Bhaskar Reddy, Effects of Thermal radiation and Chemical reaction on MHD free Convective flow past a Semi-infinite vertical porous moving plate, International Journal of Applied Mathematics and Machines, (2013), 9 (7), 23 - 46.
16. A. M. Okedoye, Unsteady MHD mixed convection flow past an oscillating plate with heat source/sink, Journal of Naval Architecture and Marine Engineering, (2014), 11, 167 - 176.
17. A. M. Rashad, A. J. Chamkha, C. RamReddy, P. V. Murthy, Influence of viscous dissipation on mixed convection in a nonDarcy porous medium saturated with a nano fluid, Heat Transfer Asian Research, (2014), 43, 397 - 411.
18. G. Singh, O. D. Makinde, Mixed convection slip flow with temperature jump along a moving plate in presence of free stream, Thermal Science, (2015), 19(1), 119 - 128.
19. M. Sheikholeslami, D. D. Ganji, Nanofluid Flow and Heat Transfer Between Parallel Plates Considering Brownian Motion using DTM. Computational Methods Appied, Mechanical Engineering, (2015), 283, 651 - 663.
20. M. Q. Brewester, Thermal Radiative Transfer and Properties, John Wiley Sons, New York, (1992).

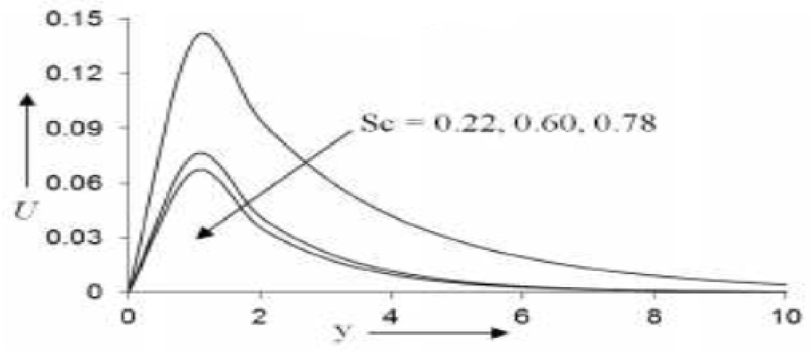

Figure-1: Schmidyt number effect on velocity
when Kc =0.2, Pr=0.71, s = 0.1, M = 3.0, K = 7.0 GRT = 1.0 GRc =0.5 and angle 30 degrees.

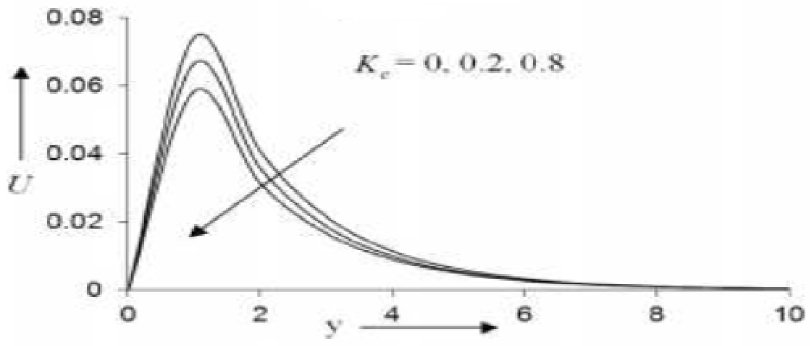

Figure-2: Chemical Reaction effects on velocity
when Sc = 0.78, Pr = 0.71 s = 0.1. M = 3.0, K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

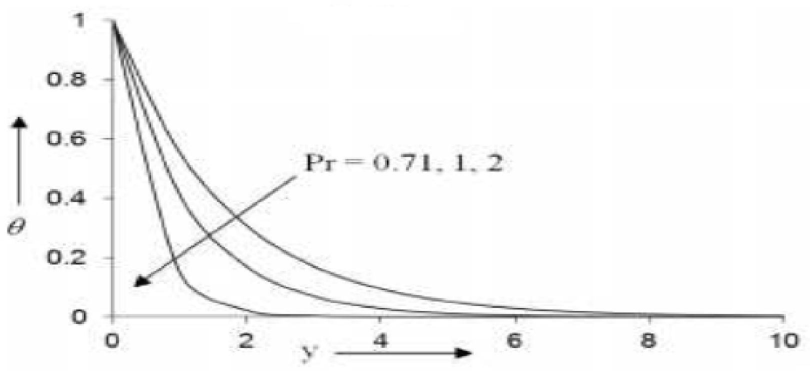

Figure-3: prandtl number effect on temperature
when Sc = 0.78, Pr = 0.71 s = 0.1. M=3.0, K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

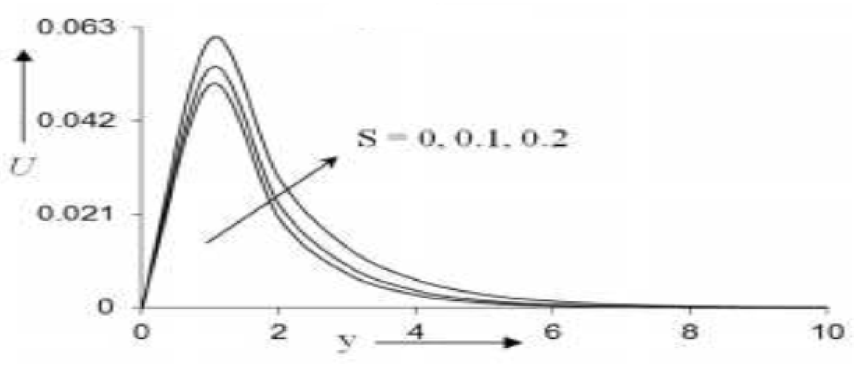

Figure-4:.heat generation parameter effects on velocity
when Sc = 0.78, Pr=0.71 s=0.1 .M=3.0, K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

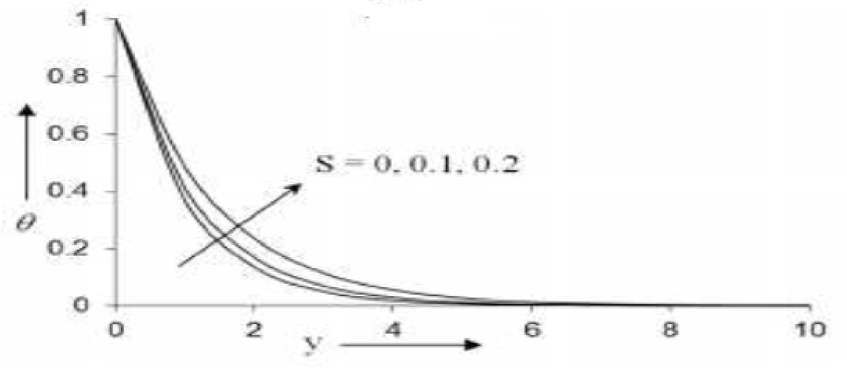

Figure-6: the heat generation paramer effect on temperature
when Sc=0.78, Pr = 0.71 s = 0.1, M = 3.0, K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

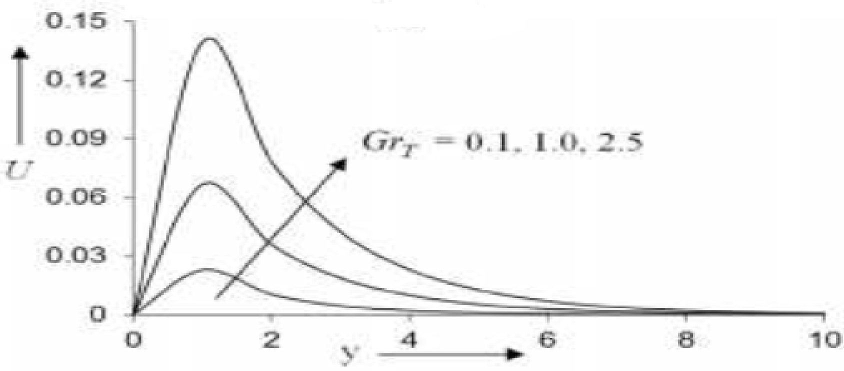

Figure-6: magnetic effects on velocity
when Sc=0.78, Pr=0.71 s = 0.1. M=3.0,K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

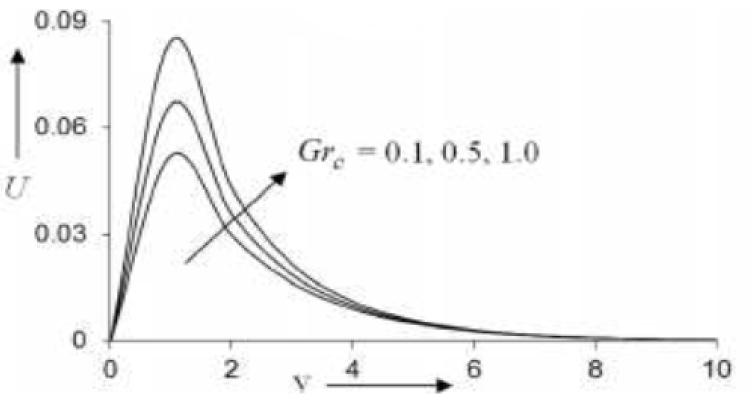

Figure-7:.porosity on velocity when Sc=0.78, Pr=0.71 s=0.1, M=3.0, K=7.0 Grt = 1.0 Grc =0.5 and angle 30 degrees

Source of support: Nil, Conflict of interest: None Declared.