International Journal of Mathematical Archive-3(2), 2012, Page: 574-585
Available online through www.ijma.info ISSN 2229 – 5046

THERMAL DIFFUSION AND RADIATION EFFECTS ON UNSTEADY MHD FLOW PAST A LINEARLY ACCELERATED VERTICAL PLATE WITH VARIABLE TEMPERATURE AND MASS DIFFUSION

A. G. Vijaya Kumar[1*], Y. Rajasekhara Goud[2], S. V. K. Varma[3] and K. Raghunath[4]

[1]Assistant Professor, Department of Mathematics, MVJ College of Engineering, Bangalore, Karnataka, INDIA
E-mail: agvijaykumar1729@gmail.com

[2]Associate Professor, Department of Mathematics(H&S), G. Pulla Reddy Engineering College, Kurnool, A.P, INDIA

[3]Professor, Department of Mathematics, S.V.University, Tirupati, A.P, INDIA
E-mail: svijayakumarvarma@yahoo.co.in

[4]Department of Mathematics, Bheema Institute of Technology and Science, Adoni, Kurnool, A.P, INDIA
E-mail: kraghunath25@gmail.com

(Received on: 10-02-12; Accepted on: 29-02-12)

ABSTRACT

The objective of the present study is to investigate thermal diffusion and radiation effects on unsteady MHD flow past a linearly accelerated vertical plate with variable temperature and mass diffusion under the influence of applied transverse magnetic field. The fluid considered here is a gray, absorbing/ emitting radiation but a non-scattering medium. At time t>0, the plate is linearly accelerated with a velocity $u = u_0 t$ *in its own plane. And at the same time, plate temperature and concentration levels near the plate raised linearly with time t. The dimensionless governing equations involved in the present analysis are solved using the Laplace transform technique. The velocity, temperature, concentration, Skin-friction, the rate or heat transfer and the rate of mass transfer are studied through graphs and tables in terms of different physical parameters like magnetic field parameter (M), radiation parameter (R), Schmidt parameter (Sc), soret number (So), Prandtl number (Pr), thermal Grashof number (Gr), mass Grashof number (Gm) and time (t).*

KEY WORDS: *MHD, thermal diffusion, linearly, Accelerated, vertical plate, radiation.*

INTRODUCTION:

The study of magneto hydro-dynamics with mass and heat transfer in the presence of radiation and diffusion has attracted the attention of a large number of scholars due to diverse applications. In astrophysics and geophysics, it is applied to study the stellar and solar structures, radio propagation through the ionosphere, etc. In engineering we find its applications like in MHD pumps, MHD bearings, etc. The phenomenon of mass transfer is also very common in theory of stellar structure and observable effects are detectable on the solar surface. In free convection flow the study of effects of magnetic field play a major rule in liquid metals, electrolytes and ionized gases. In power engineering, the thermal physics of hydro magnetic problems with mass transfer have enormous applications. Radiative flows are encountered in many industrial and environment processes, e.g. heating and cooling chambers, fossil fuel combustion energy processes, evaporation from large open water reservoirs, astrophysical flows, solar power technology and space vehicle re-entry.

MHD effects on impulsively started vertical infinite plate with variable temperature in the presence of transverse magnetic field were studied by Soundalgekar et al. [12]. The effects of transversely applied magnetic field, on the flow of an electrically conducting fluid past an impulsively started infinite isothermal vertical plate were also studied by Soundalgekar et al. [11]. The dimensionless governing equations were solved using Laplace transform technique. Kumari and nath [8] studied the development of the asymmetric flow of a viscous electrically conducting fluid in the forward stagnation point region of a two-dimensional body and over a stretching surface was set into impulsive motion

***Corresponding author: A. G. Vijaya Kumar[1]*, *E-mail: agvijaykumar1729@gmail.com**

from the rest. The governing equations were solved using finite difference scheme. The radiative free convection flow of an optically thin gray-gas past semi-infinite vertical plate studied by Soundalgekar and Takhar [13]. Hossain and Takhar have considered radiation effects on mixed convection along an isothermal vertical plate [5]. In all above studies the stationary vertical plate considered. Raptis and Perdikis [10] studied the effects of thermal-radiation and free convection flow past a moving vertical plate. The governing equations were solved analytically. Das et al [4] have considered radiation effects on flow past an impulsively started infinite isothermal vertical plate. The governing equations were solved by the Laplace transform technique. Muthucumaraswamy and Janakiraman [9] have studied MHD and radiation effects on moving isothermal vertical plate with variable mass diffusion.

Alam and Sattar [3] have analyzed the thermal-diffusion effect on MHD free convection and mass transfer flow. Jha and Singh [6] have studied the importance of the effects of thermal-diffusion(mass diffusion due to temperature gradient). Alam et al [1] studied the thermal-diffusion effect on unsteady MHD free convection and mass transfer flow past an impulsively started vertical porous plate. Recently, Alam et al [2], studied combined free convection and mass transfer flow past a vertical plate with heat generation and thermal-diffusion through porous medium. Very recently, Rajesh et al [14] and Vijaya Kumar et al [15] studied thermal diffusion and radiation effects on MHD flow past a vertical plate with variable temperature and mass diffusion.

This paper deals with the effects of thermal-diffusion and radiation on unsteady MHD flow past an impulsively started linearly accelerated infinite vertical plate with variable temperature and mass diffusion in the presence of transverse applied magnetic field. The dimensionless governing equations involved in the present analysis are solved using Laplace transform technique. The solutions are expressed in terms of exponential and complementary error functions.

MATHEMATICAL FORMULATION:

Thermal-diffusion and radiation effects on unsteady MHD flow past of a viscous incompressible, electrically conducting, radiating fluid past an impulsively started linearly accelerated infinite vertical plate with variable temperature and mass diffusion in the presence of transverse applied magnetic field are studied. The plate is taken along $x'-$-axis in vertically upward direction and $y'-$axis is taken normal to the plate. Initially it is assumed that the plate and fluid are at the same temperature T'_∞ and concentration level C'_∞ in stationary condition for all the points. At time $t'>0$, the plate is linearly accelerated with a velocity $u=u_0t'$ in the vertical upward direction against to the gravitational field. And at the same time the plate temperature is raised linearly with time t and also the mass is diffused from the plate to the fluid is linearly with time. A transverse magnetic field of uniform strength B_0 is assumed to be applied normal to the plate. The viscous dissipation and induced magnetic field are assumed to be negligible. The fluid considered here is gray, absorbing/emitting radiation but a non-scattering medium. Then under by usual Boussinesq's approximation, the unsteady flow is governed by the following equations.

$$\frac{\partial u'}{\partial t'} = g\beta(T'-T'_\infty) + g\beta^*(C'-C'_\infty) + v\frac{\partial^2 u'}{\partial y'^2} - \frac{\sigma\beta_0^2 u'}{\rho} \tag{1}$$

$$\rho c_p \frac{\partial T'}{\partial t'} = \kappa\frac{\partial^2 T'}{\partial y'^2} - \frac{\partial q_r}{\partial y'} \tag{2}$$

$$\frac{\partial C'}{\partial t'} = D\frac{\partial^2 C'}{\partial y'^2} + D_1\left(\frac{\partial^2 T'}{\partial y'^2}\right) \tag{3}$$

With the following initial and boundary conditions

$$t' \le 0 : u' = 0, \quad T' = T'_\infty, \quad C' = C'_\infty, \ for\,all\ \ y'$$

$$\begin{aligned} t' > 0 :\ & u' = u_0 t',\ T' = T'_\infty + (T'_w - T'_\infty)At', \\ & C' = C'_\infty + (C'_w - C'_\infty)At' \quad at \quad y' = 0 \\ u' = 0,\ & T' \to T'_\infty,\ \ C' \to C'_\infty\ \ as\ \ y' \to \infty \end{aligned} \tag{4}$$

Where $A = \frac{u_0^2}{v}$.

The local radiant for the case of an optically thin gray gas is expressed by

$$\frac{\partial q_r}{\partial y'} = -4a^* \sigma \left(T_\infty'^4 - T'^4 \right) \tag{5}$$

It is assumed that the temperature differences within the flow are sufficiently small and that T'^4 may be expressed as a linear function of the temperature. This is obtained by expanding T'^4 in a Taylor series about T'_∞ and neglecting the higher order terms, thus we get

$$T'^4 \cong 4T_\infty'^3 T' - 3T_\infty'^4 \tag{6}$$

From equations (5) and (6), equation (2) reduces to

$$\rho C_p \frac{\partial T'}{\partial t'} = \kappa \frac{\partial^2 T'}{\partial y'^2} + 16a^* \; \sigma T_\infty'^3 \left(T'_\infty - T' \right) \tag{7}$$

On introducing the following non-dimensional quantities:

$$u = \frac{u'}{u_0},\; t = \frac{t' u_0^2}{v},\; y = \frac{y' u_0}{v},\; \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty},\; C = \frac{C' - C'_\infty}{C'_w - C'_\infty}, P_r = \frac{\mu C_\rho}{\kappa}, S_0 = \frac{D_1 (T'_w - T'_\infty)}{v (C'_w - C'_\infty)}$$
$$G_r = \frac{g\beta v \left(T'_w - T'_\infty \right)}{u_0^3},\; G_m = \frac{g\beta^\bullet v \left(C'_w - C'_\infty \right)}{u_0^3},$$
$$S_c = \frac{v}{D},\; M = \frac{\sigma B_0^2 v}{\rho u_0^2},\; R = \frac{16 a^\bullet v^2 \sigma T_\infty'^3}{k u_0^2} \tag{8}$$

We get the following governing equations which are dimensionless

$$\frac{\partial u}{\partial t} = G_r \theta + G_m C + \frac{\partial^2 u}{\partial y^2} - Mu, \tag{9}$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{\Pr} \frac{\partial^2 \theta}{\partial y^2} - \frac{R}{\Pr} \theta, \tag{10}$$

$$\frac{\partial C}{\partial t} = \frac{1}{Sc} \frac{\partial^2 C}{\partial y^2} + S_o \frac{\partial^2 \theta}{\partial y^2} \tag{11}$$

The initial and boundary conditions in dimensionless form as follows:

$$\begin{aligned} &t' \le 0 : u = 0, \quad \theta = 0, \quad C = 0 \;\; for\ all \quad y, \\ &t > 0 : \; u = t, \;\; \theta = t, \quad C = t \qquad at \qquad y = 0, \\ &u \to 0, \quad \theta \to 0, \quad c \to 0 \qquad as \qquad y \to \infty. \end{aligned} \tag{12}$$

SOLUTION OF THE PROBLEM:

The appeared physical parameters are defined in the nomenclature. The dimensionless governing equations from (9) to (11), subject to the boundary conditions (12) are solved by usual Laplace transform technique and the solutions are expressed in terms of exponential and complementary error functions.

$$\theta(y,t) = \left[\left(\frac{t}{2} + \frac{y \Pr}{4\sqrt{R}} \right) \exp\left(y\sqrt{R} \right) erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}} + \sqrt{\frac{Rt}{\Pr}} \right) + \left(\frac{t}{2} - \frac{y \Pr}{4\sqrt{R}} \right) \exp\left(-y\sqrt{R} \right) erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}} - \sqrt{\frac{Rt}{\Pr}} \right) \right] \tag{13}$$

$$C(y,t)=(1+b)\left[\left(t+\frac{y^2Sc}{2}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}\right)-y\sqrt{\frac{tSc}{\pi}}\exp\left(-\frac{y^2Sc}{4t}\right)\right]+\left(d-\frac{b}{c}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}\right)$$
$$-\frac{1}{2}\left(d-\frac{b}{c}\right)\exp(-ct)\left[\exp\left(y\sqrt{-cSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{-ct}\right)+\exp\left(-y\sqrt{-cSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{-ct}\right)\right]$$
$$-\frac{1}{2}\left(d-\frac{b}{c}\right)\left[\exp(y\sqrt{R})erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\frac{Rt}{\Pr}}\right)+\exp(-y\sqrt{R})erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\frac{Rt}{\Pr}}\right)\right]$$
$$-b\left[\left(\frac{t}{2}+\frac{y\Pr}{4\sqrt{R}}\right)\exp(y\sqrt{R})erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\frac{Rt}{\Pr}}\right)+\left(\frac{t}{2}-\frac{y\Pr}{4\sqrt{R}}\right)\exp(-y\sqrt{R})erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\frac{Rt}{\Pr}}\right)\right]$$
$$+\frac{1}{2}\left(d-\frac{b}{c}\right)\exp(-ct)\left[\exp\left(y\sqrt{R-c\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\left(\frac{R}{\Pr}-c\right)t}\right)+\exp\left(-y\sqrt{R-c\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\left(\frac{R}{\Pr}-c\right)t}\right)\right]$$

$$u(y,t)=A_1\left[\left(\frac{t}{2}+\frac{y\Pr}{4\sqrt{R}}\right)\exp\left(y\sqrt{R}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\frac{Rt}{\Pr}}\right)+\left(\frac{t}{2}-\frac{y\Pr}{4\sqrt{R}}\right)\exp\left(-y\sqrt{R}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\frac{Rt}{\Pr}}\right)\right]$$
$$+(1-A_1-A_2)\left[\left(\frac{t}{2}+\frac{y}{4\sqrt{M}}\right)\exp(y\sqrt{M})erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{Mt}\right)+\left(\frac{t}{2}-\frac{y}{4\sqrt{M}}\right)\exp(-y\sqrt{M})erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{Mt}\right)\right]$$
$$+\frac{A_3}{2}\exp(-ct)\left[\exp\left(y\sqrt{R-c\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\left(\frac{R}{\Pr}-c\right)t}\right)+\exp\left(-y\sqrt{R-c\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\left(\frac{R}{\Pr}-c\right)t}\right)\right]$$
$$+\frac{A_4}{2}\exp(-ct)\left[\exp\left(y\sqrt{-cSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{-ct}\right)+\exp\left(-y\sqrt{-cSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{-ct}\right)\right]$$
$$+\frac{A_5}{2}\exp(-lt)\left[\exp\left(y\sqrt{M-l}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{(M-l)t}\right)+\exp\left(-y\sqrt{M-l}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{(M-l)t}\right)\right]$$
$$-\frac{A_5}{2}\exp(-lt)\left[\exp\left(y\sqrt{R-l\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\left(\frac{R}{\Pr}-l\right)t}\right)+\exp\left(-y\sqrt{R-l\Pr}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\left(\frac{R}{\Pr}-l\right)t}\right)\right]$$
$$+\frac{A_6}{2}\exp(nt)\left[\exp\left(y\sqrt{M+n}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{(M+n)t}\right)+\exp\left(-y\sqrt{M+n}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{(M+n)t}\right)\right]$$
$$-\frac{A_6}{2}\exp(nt)\left[\exp\left(y\sqrt{nSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{nt}\right)+\exp\left(-y\sqrt{nSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{nt}\right)\right]$$
$$+\frac{A_7}{2}\left[\exp\left(y\sqrt{R}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}+\sqrt{\frac{Rt}{\Pr}}\right)+\exp\left(-y\sqrt{R}\right)erfc\left(\frac{y\sqrt{\Pr}}{2\sqrt{t}}-\sqrt{\frac{Rt}{\Pr}}\right)\right]+A_8erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}\right)$$
$$-\frac{1}{2}(A_7+A_8)\left[\exp(y\sqrt{M})erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{Mt}\right)+\exp(-y\sqrt{M})erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{Mt}\right)\right] \qquad (15)$$

Where $b=S_0Sc,\ c=\dfrac{R}{\Pr-Sc},d=\dfrac{b\Pr}{R},l=\dfrac{R-M}{Sc-1},n=\dfrac{M}{Sc-1},$

$A_1=\dfrac{bGm-Gr}{R-M},A_2=\dfrac{(1+b)Gm}{M},$

$$A_3 = \frac{bGm(R - c\Pr)}{cR(R - M + c - c\Pr)},$$

$$A_4 = \frac{bGm(R - c\Pr)}{cR(R - M + c - c\Pr)},$$

$$A_5 = \frac{(\Pr - 1)[RGr(R - M + c - c\Pr) + Gmbc(M\Pr - R)]}{R(R - M)^2(R - M + c - c\Pr)}$$

$$A_6 = \frac{Gm(Sc - 1)[M(R + bc\Pr) + cR(1 + b)(Sc - 1)]}{M^2 R(M - c + cSc)}$$

$$A_7 = \frac{cR(\Pr - 1)(Gr - bGm) + Gmb(R - M)(c\Pr - R)}{cR(R - M)^2}$$

$$A_8 = \frac{Gm[cR(Sc - 1) + M\Pr bc - bR(M + c - cSc)]}{cM^2 R}$$

NUSSELT NUMBER:

From temperature field, now we study Nusselt number (rate of change of heat transfer) which is given in non-dimensional form as

$$Nu = -\left[\frac{\partial\theta}{\partial y}\right]_{y=0} \tag{17}$$

From equations (13) and (17), we get Nusselt number as follows:

$$Nu = \left[t\sqrt{R}erf\sqrt{\frac{Rt}{\Pr}} + \sqrt{\frac{t\Pr}{\pi}}\exp\left(-\frac{Rt}{\Pr}\right) + \frac{\Pr}{2\sqrt{R}}erf\sqrt{\frac{Rt}{\Pr}}\right]$$

SHERWOOD NUMBER:

From concentration field, now we study Sherwood number (rate of change of mass transfer) which is given in non-dimensional form as

$$Sh = -\left[\frac{\partial C}{\partial y}\right]_{y=0} \tag{18}$$

From equations (14) and (18), we get Sherwood number as follows:

$$\begin{aligned} Sh = 2(1+b)\sqrt{\frac{tSc}{\pi}} + \left(d - \frac{b}{c}\right)\sqrt{\frac{Sc}{\pi t}} - \left(d - \frac{b}{c}\right)\exp(-ct)\left[\sqrt{\frac{Sc}{\pi t}}\exp(ct) + \sqrt{-cSc}erf\sqrt{-ct}\right] \\ -\left(d - \frac{b}{c}\right)\left[\sqrt{\frac{\Pr}{\pi t}}\exp\left(-\frac{Rt}{\Pr}\right) + \sqrt{R}erf\sqrt{\frac{Rt}{\Pr}}\right] \\ +\left(d - \frac{b}{c}\right)\exp(-ct)\left[\sqrt{\frac{\Pr}{\pi t}}\exp\left(-\frac{Rt}{\Pr} + ct\right) + \sqrt{R - c\Pr}erf\sqrt{\left(\frac{R}{\Pr} - c\right)t}\right] \\ -b\left[t\sqrt{R}erf\sqrt{\frac{Rt}{\Pr}} + \sqrt{\frac{t\Pr}{\pi}}\exp\left(-\frac{Rt}{\Pr}\right) + \frac{\Pr}{2\sqrt{R}}erf\sqrt{\frac{Rt}{\Pr}}\right] \end{aligned}$$

RESULTS AND DISCUSSIONS:

In order to get the physical insight into the problem, we have plotted velocity, temperature, concentration, the rate of heat transfer and the rate of mass transfer for different values of the physical parameters like Radiation parameter (R), Magnetic parameter(M), Soret number(So), Schmidt number (Sc), Thermal Grashof number (Gr), Mass Grashof number (Gm), time (t) and Prandtl number (Pr) in figures 1 to 14 for the cases of heating ($Gr < 0$, $Gm < 0$) and cooling ($Gr > 0$, $Gm > 0$) of the plate at time $t = 0.4$. The heating and cooling take place by setting up free-convection current due to temperature and concentration gradient.

Figure (1) displays the influences of M (magnetic parameter) on the velocity field in cases of cooling and heating of the plate. It is found that the velocity decreases with increasing of magnetic parameter M in case of cooling, while it increases in the case of heating of the plate. It is seen that from Figure (2) the velocity increases with increase in So (Soret number) in the case cooling of the plate but a reverse effect is identified in the case of heating of the plate. From figure (3) and (4) it is observed that with the increase of radiation parameter R or Schmidt number Sc, the velocity increases up to certain y value (distance from the plate) and decreases later for the case of cooling of the plate. But a reverse effect is observed in the case of heating of the plate. The velocity profiles for different values of time t are shown in Figure (5), it is seen that as time t increases the velocity increases gradually in the case of cooling of the plate and the trend is just reversed in the case of heating of the plate.

The temperature of the flow field is mainly affected by the flow parameters, namely, Radiation parameter (R) and the prandtl number (Pr). The effects of these parameters on temperature of the flow field are shown in figures 6 & 7 respectively. Figure 6 depicts the temperature profiles against y (distance from the plate) for various values of radiation parameter (R) at time $t=0.2$ & 0.4 keeping Prandtl number (Pr) as constant. It is observed that as radiation parameter R increases the temperature of the flow field decreases at all the points. Figure 7 shows the plot of temperature of the flow field against for different values of Prandtl number (Pr) at time $t = 0.2$ & $t =0.4$ taking radiation parameter (R) as constant. It is observed that the temperature of the flow field decreases in magnitude as Pr increases. It is also observed that the temperature for air ($Pr=0.71$) is greater than that of water ($Pr=7.0$). This is due to the fact that thermal conductivity of fluid decreases with increasing Pr, resulting decreases in thermal boundary layer.

The concentration distributions of the flow field are displayed through figures 8, 9 &10. It is affected by three flow parameters, namely Soret number (So), Schmidt number (Sc) and radiation parameter(R) respectively. From figure 8 it is clear that the concentration increases with an increase in So (soret number). Figure 8 & 10 reveal the effect of Sc and R on the concentration distribution of the flow field. The concentration distribution is found to increase faster up to certain y value (distance from the plate) and decreases later as the Schmidt parameter (Sc) or Radiation parameter (R) become heavier.

Nusselt number is presented in Figure 11 against time t. From this figure the Nusselt number is observed to increase with increase in R for both water ($Pr=7.0$) and air ($Pr=0.71$). It is also observed that Nusselt number for water is higher than that of air ($Pr=0.71$). The reason is that smaller values of Pr are equivalent to increasing the thermal conductivities and therefore heat is able to diffuse away from the plate more rapidly than higher values of Pr, hence the rate of heat transfer is reduced. Figure 12, 13 & 14 represent Sherwood number against time t. And it is observed that the Sherwood number decreases with increase in Sc (Schmidt number), So (soret number) and R (radiation parameter).

REFERENCES:

[1] M.S.Alam, M.M. Rahman and M.A. Maleque, Local similarity solutions for unsteady MHD free convection and mass transfer flow past an impulsively started vertical porous plate with Dufour and Soret effects, Thammasat int.j.sci.tech. 10(3) (2005), 1-8.

[2] M.S.Alam, M.M.Rahman and M.A. Samad, Numerical study of the combined free-forced convection and mass transfer flow past a vertical porous plate in a porous medium with heat generation and thermal diffusion , Nonlin. Anal.Model. Control 11(4) (2006), 331-343

[3] M.M. Alam and M. A. Sattar, Transient MHD heat and mass transfer flow with thermal diffusion in a rotating system, J. Energy Heat Mass trans. 21 (1999)m 9-21.

[4] U . N. Das, R.K. Deka and V.M. Soundalgekar , Radiation effects on flow past an impulsively started vertical infinite plate, J.theo. Mech. 1(1996), 111-115.

[5] M. A. Hossain and H. S. Takhar, Radiation effect on mixed convection along a vertical plate with uniform surface temperature, Heat Mass Trans. 31(1996), 243-248.

[6] B. K. Jha and A. K. Singh, Soret effects on free-convection and mass transfer flow in the Stokes problem for a infinite vertical plate, Astrophys.Space Sci. 173(2) (1990).

[7] N. G. Kafoussias, MHD thermal –diffusion effects on free convective and mass transfer flow over an infinite vertical moving plate. Astrophys.Space Sci. 192(1) (1992), 11-19.

[8] M. Kumari and G. Nath , Development of two-dimensional boundary layer with an applied magnetic field due to an impulsive motion, Indian J. pure Appl. Math. 30 (1999), 695-708.

[9] R. Muthucumaraswamy and B. Janakiraman, MHD and radiation effects on moving isothermal vertical plate with variable mass diffusion, Theo. Appl. Mech. 33(1) (2006), 17-29.

[10] A. Raptis and C. Perdikis, Radiation and free convection flow past a moving plate, Int. J.Appl Mech. Eng. 4(1999), 817-821.

[11] V.M. Soundalgekar , S.K. Gupta and N.S. Birajdar , Effects of mass transfer and free convection currents on MHD Stokes problem for a vertical plate, Nuclear Eng. Des. 53(1979), 339-346.

[12] V.M.Soundalgekar, M.R.Patil and M.D. Jahagirdar, MHD Stokes problem for a vertical plate with variable temperature, Nuclear Eng. Des. 64(1981), 39-42.

[13] V.M. Soundalgekar and H.S. Takhar, Radiation effects on free convection flow past a semi-infinite vertical plate , Model. Measure.Comrol (1993), 31-40.

[14] V. Rajesh and S.V.K. Varma, Thermal diffusion and radiation effects on MHD flow past an infinite vertical plate with variable temperature and mass diffusion, JP Journal of Heat and Mass Transfer, Vol3, Issue1,Feb(2009).

[15] A.G. Vijaya Kumar and S.Vijaya Kumar Varma, Thermal diffusion and Radiation effects on MHD flow through porous medium with variable temperature and variable mass diffusion, Int. Journal of Fluids Engineering, Vol.3, No.3(2011), pp. 353-368.

GRAPHS:

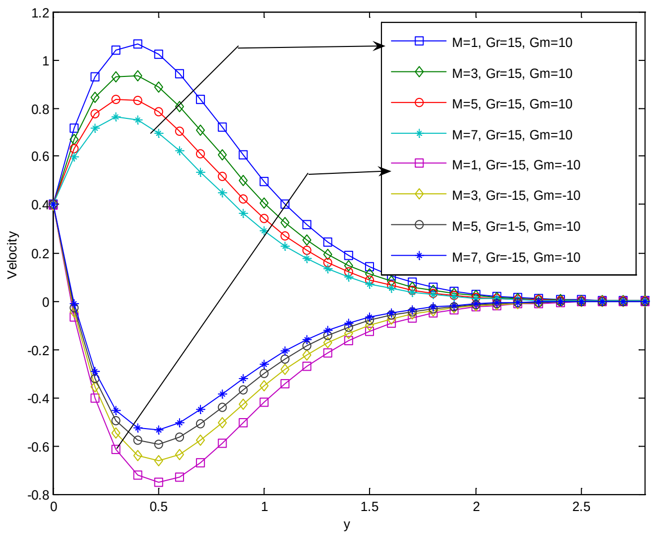

Figure 1: Velocity profiles when so=5, Sc=2.01, Pr=0.71, R=15 and t=0.4

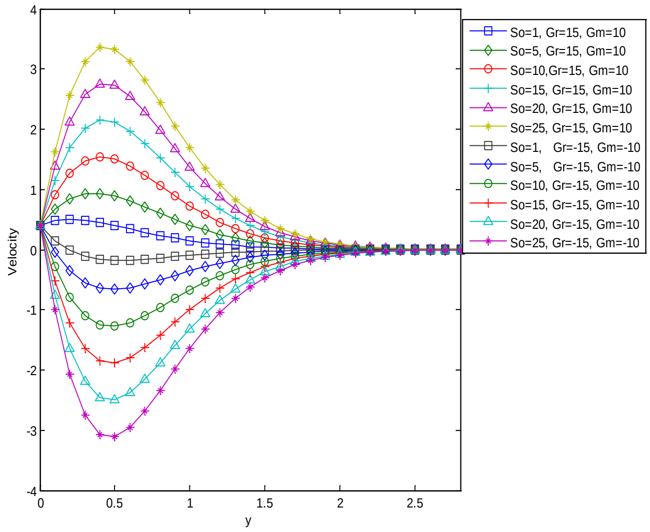

Figure 2: Velocity profiles when M=3, Sc=2.01, Pr=0.71, R=15 and t=0.4

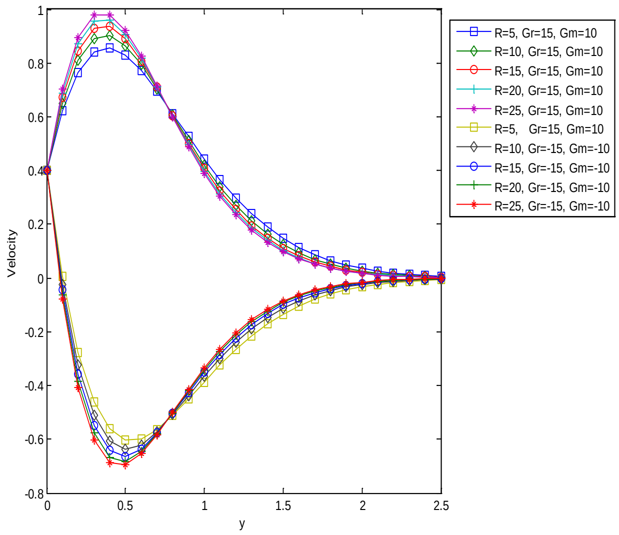

Figure 3: Velocity profiles when so=5, Sc=2.01, M=3, Pr=0.71 and t=0.4

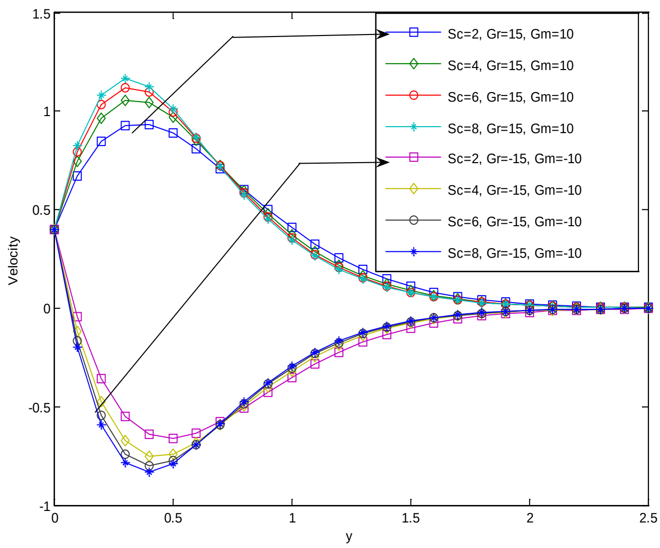

Figure 4: Velocity profiles when so=5, M=3, Pr=0.71, R=15 and t=0.4

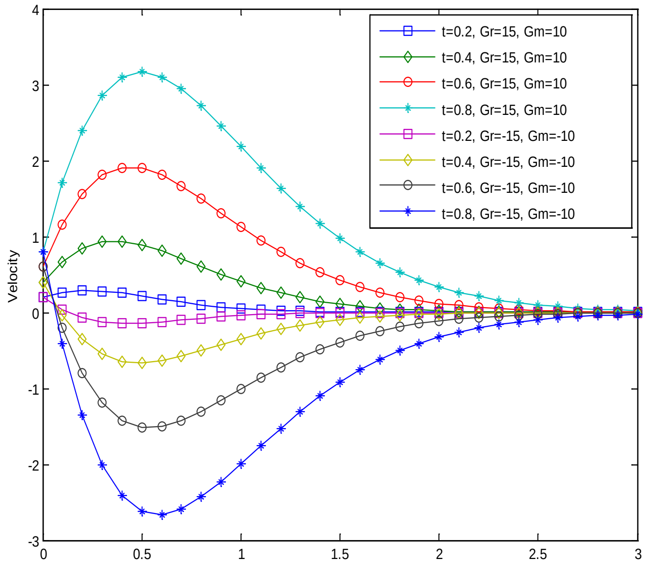

Figure 5: Velocity profiles when so=5, Sc=2.01, M=3, Pr=0.71, R=15

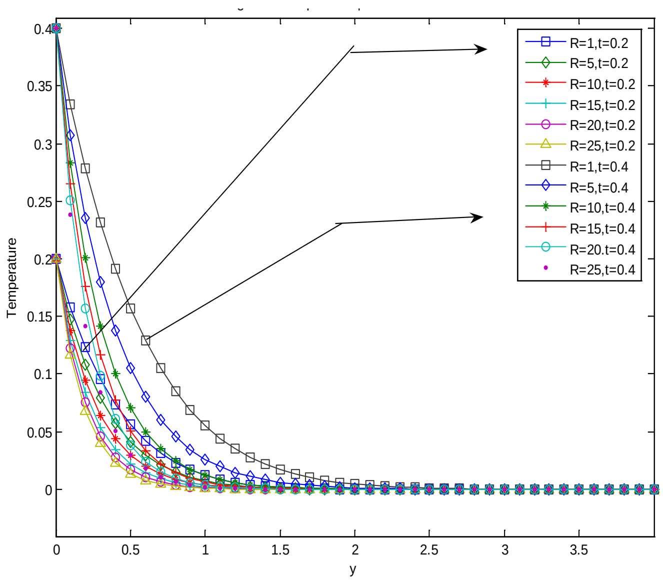

Figure 6: Temperature profiles when Pr=0.71

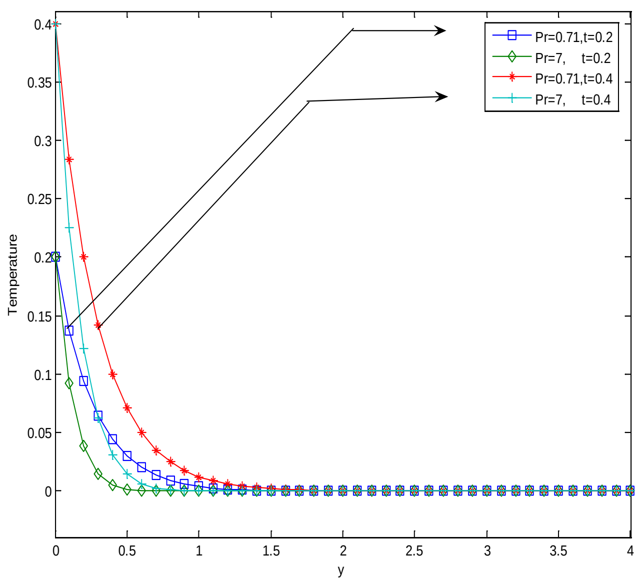

Figure 7: Temperature profiles when R=10

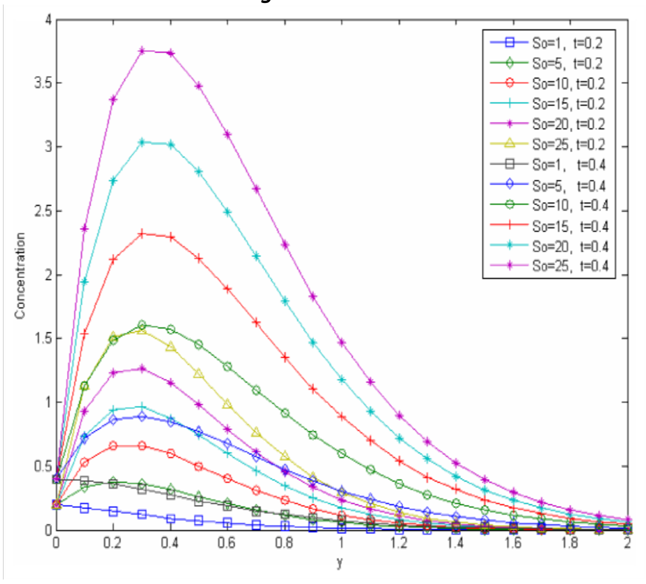

Figure 8: Concentration profiles when R=5, Sc=2.01 and Pr=0.71

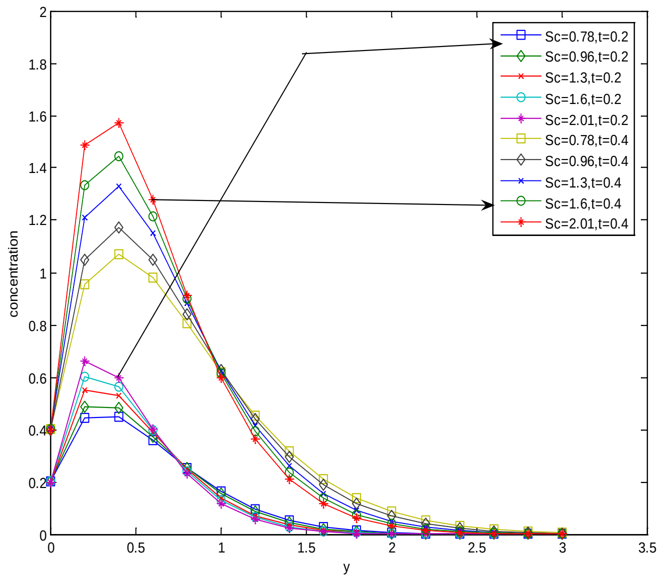

Figure 9: Concentration profiles when So=10, Pr=0.71 and R=5

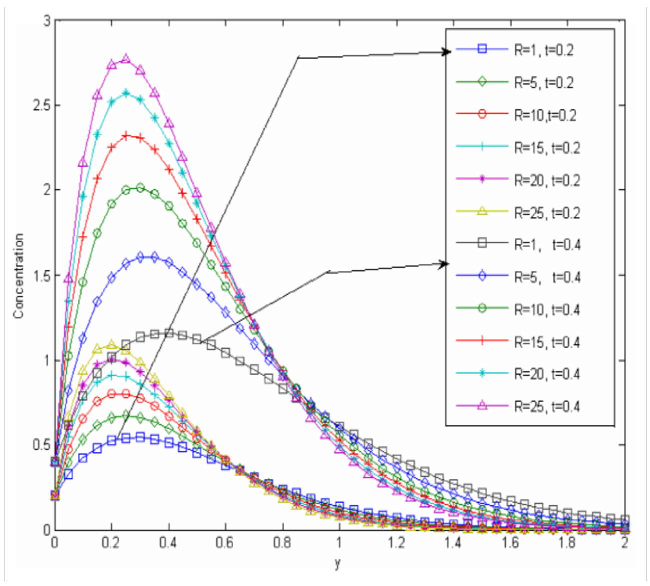

Figure 10: Concentration profiles for different R when So=5, Sc=2.01 and Pr=0.71

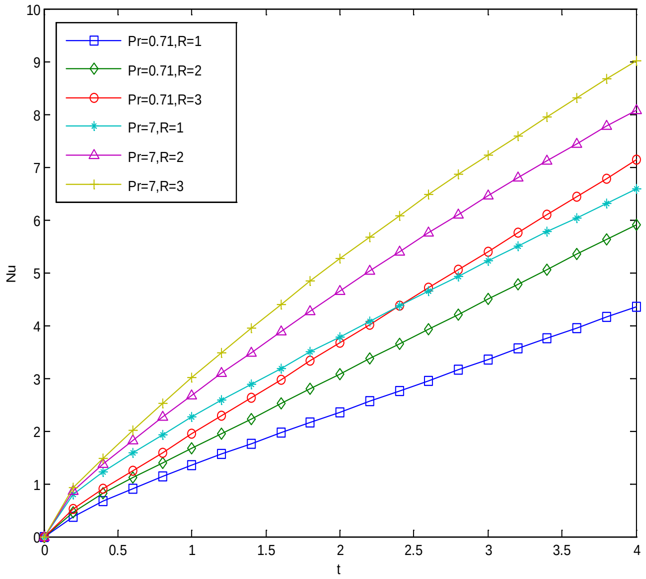

Figure 11: Nusselt Number

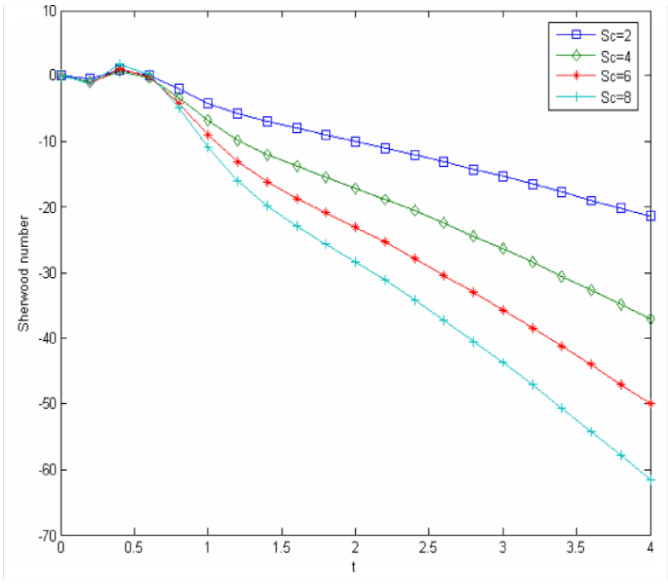

Figure 12: Sherwood number for different Sc

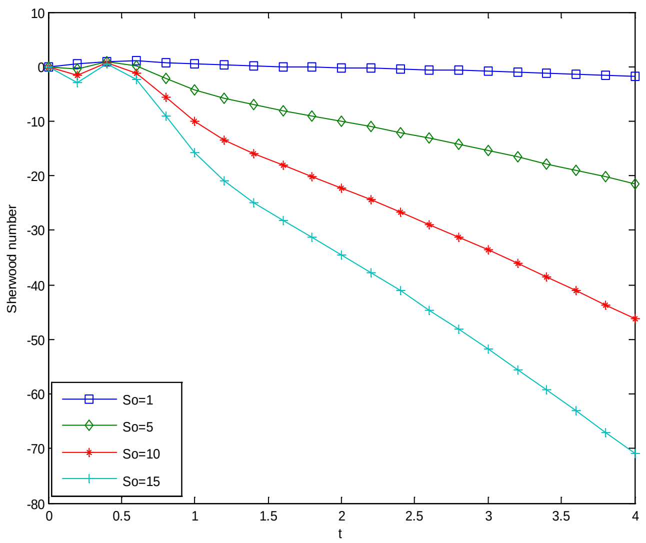

Figure 13: Sherwood number for different So

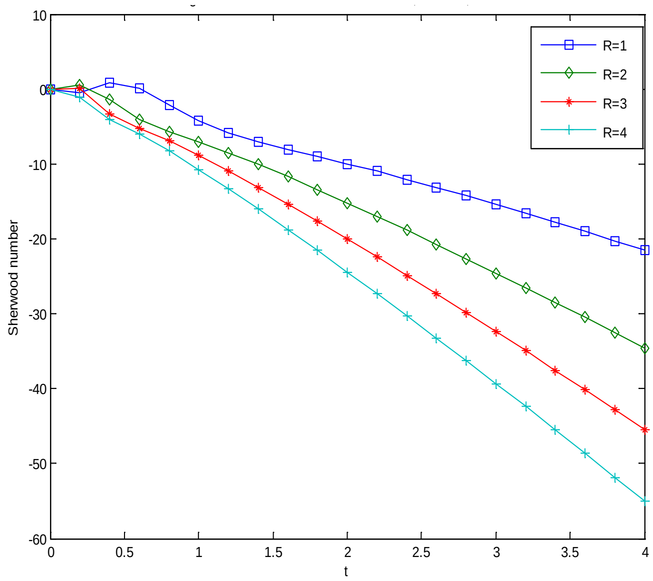

Figure 14: Sherwood number for different R

NOMENCLATURE:

a^*	Absorption coefficient
a	Accelerated parameter
B_0	External magnetic field
C'	Species concentration
C'_w	Concentration of the plate
C'_∞	Concentration of the fluid far away from the plate
C	Dimensionless concentration
C_p	Specific heat at constant pressure
D	Chemical molecular diffusivity
D_1	Coefficient of thermal diffusivity
g	Acceleration due to gravity
G_r	Thermal Grashof number
G_m	Mass Grashof number
M	Magnetic field parameter
Nu	Nusselt number
Pr	Prandtl number
q_r	Radiative heat flux in the y- direction
R	Radiative parameter
Sc	Schmidt number
So	Soret number
Sh	Sherwood number
T'	Temperature of the fluid near the plate
T'_w	Temperature of the plate
T'_∞	Temperature of the fluid far away from the plate
t'	Time
t	Dimensionless time
u'	Velocity of the fluid in the x' - direction
u_0	Velocity of the plate
u	Dimensionless velocity
y'	Co-ordinate axis normal to the plate
y	Dimensionless co-ordinate axis normal to the plate

Greek symbols:

κ	Thermal conductivity of the fluid
α	Thermal diffusivity
β	Volumetric coefficient of thermal expansion
β^*	Volumetric coefficient of expansion with concentration
μ	Coefficient of viscosity
υ	Kinematic viscosity
ρ	Density of the fluid
σ	Electric conductivity
θ	Dimensionless temperature
erf	Error function
erfc	Complementary error function

Subscripts:

ω	Conditions on the wall
∞	Free stream conditions

****