ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING
Tome X (Year 2012) – FASCICULE 2 (ISSN 1584 – 2665)

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CHEMICAL REACTION AND RADIATION EFFECTS ON MHD FREE CONVECTIVE FLOW PAST AN EXPONENTIALLY ACCELERATED VERTICAL PLATE WITH VARIABLE TEMPERATURE AND VARIABLE MASS DIFFUSION

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ABSTRACT: *An analytical study is performed to investigate the effects of chemical reaction and radiation on unsteady MHD flow past an exponentially accelerated vertical plate with variable temperature and variable mass diffusion in the presence of applied transverse magnetic field. It is assumed that the effect of viscous dissipation is negligible in the energy equation and there is a first order chemical reaction between the diffusing species and the fluid. The flow is assumed to be in x' - direction which is taken along the infinite vertical plate in the upward direction and y' - axis is taken normal to the plate. At time t' > 0, the both temperature and species concentration levels near the plate are raised linearly with time time t. A general exact solution of the governing partial differential equations is obtained by usual Laplace transform technique. The velocity, temperature and concentration fields are studied for different physical parameters like thermal Grashof number (Gr), mass Grashof number (Gm), Schmidt number (Sc), Prndtl number (Pr), radiation parameter (R), magnetic field parameter (M), accelerated parameter (a) and time (t) graphically while the effect of chemical reaction parameter (K) is presented through tables.*
KEYWORDS: *MHD, thermal radiation, chemical reaction, variable temperature, variable mass diffusion*

INTRODUCTION

Mass diffusion rates can be changed tremendously with chemical reactions. The chemical reaction effects depend whether the reaction is homogeneous or heterogeneous. This depends on whether they occur at an interface or as a single phase volume reaction. In well-mixed systems, the reaction is heterogeneous, if it takes place at an interface and homogeneous, if it takes place in solution. In majority cases, a chemical reaction depends on the concentration of the species itself. A reaction is said to be first order, if the rate of reaction is directly proportional to the concentration itself (cussler [3]). A few representative areas of interest in which heat and mass transfer combined along with chemical reaction play an important role in chemical industries like in food processing and polymer production. Chambre and Young [2] have analyzed a first order chemical reaction in the neighborhood f a horizontal plate. Das et al. [4] have studied the effect of homogeneous first order chemical reaction on the flow past an impulsively started vertical plate with uniform heat flux and mass transfer. Again, mass transfer effects on moving isothermal vertical plate in the presence of chemical reaction studied by Das et al. [5]. The dimensionless governing equations were solved by the usual Laplace Transform technique.

Gupta et al. [6] studied free convection flow past a linearly accelerated vertical plate in the presence of viscous dissipative heat using perturbation method. Kafousias and Raptis [7] extended this problem to include mass transfer effects subjected to variable suction or injection. Mass transfer effects on flow past an accelerated vertical plate a uniformly accelerated vertical plate was studied by Soundalgekar [9] again, Mass transfer effects on flow past an accelerated vertical plate with uniform heat flux was analyzed by the Singh and Singh [8]. Basant kumar Jha and Ravindra Prasad [1] analyzed mass transfer effects on the flow past an accelerated infinite vertical plate with heat sources. Very recently, Muthucumaraswamy et al. [9] (2011) studied first order chemical reaction and thermal radiation effects on unsteady flow past an accelerated isothermal vertical plate.

In this paper, an investigation is carried out to study the effects of radiation on unsteady MHD free convective flow past an exponentially accelerated vertical plate with variable temperature and also with variable mass diffusion in the presence of a first order homogenous chemical reaction and applied transverse magnetic field. The dimensionless governing equations are solved using Laplace transform technique. And the solutions are derived in terms of exponential and complementary error functions.

MATHEMATICAL FORMULATION

In this problem, we consider the unsteady hydro magnetic radiative flow of viscous incompressible fluid past an exponentially accelerated infinite vertical plate with variable temperature and also with variable mass diffusion in the presence of chemical reaction of first order and applied transverse magnetic field. Initially, the plate and the fluid are at the same temperature T'_∞ in the stationary condition with concentration level C'_∞ at all the points. At time t' > 0, the plate is exponentially accelerated with a velocity $u = u_0 \exp(a't')$ in its own plane. And at the same time the temperature of the fluid near the plate is raised linearly with time t and species concentration level near the plate is also increased linearly with time. All the physical properties of the fluid are considered to be constant except the influence of the body-force term. A transverse magnetic field of uniform strength B_0 is assumed to be applied normal to the plate. Then under usual Boussinesq's approximation, the unsteady flow is governed by the following set of equations.

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

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

$$\frac{\partial C'}{\partial t'} = D\frac{\partial^2 C'}{\partial y'^2} - K_l(C' - C'_\infty) \tag{3}$$

With the following initial and boundary conditions

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

where $A = \frac{u_0^2}{\nu}$ *The local radiant for the case of an optically thin gray gas is expressed by*

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

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

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

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

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

On introducing the following non-dimensional quantities

$$\begin{aligned} &u = \frac{u'}{u_0}, \ t = \frac{t'u_0^2}{\nu}, \ y = \frac{y'u_0}{\nu}, \ \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty}, \ C = \frac{C' - C'_\infty}{C'_w - C'_\infty}, \ a = \frac{a'\nu}{u_0^2}, \\ &G_r = \frac{g\beta\nu(T'_w - T'_\infty)}{u_0^3}, \ G_m = \frac{g\beta^\bullet\nu(C'_w - C'_\infty)}{u_0^3}, \quad P_r = \frac{\mu C_\rho}{\kappa}, \ S_c = \frac{\nu}{D}, \\ &M = \frac{\sigma B_0^2\nu}{\rho u_0^2}, \ R = \frac{16a^\bullet\nu^2\sigma T'^3_\infty}{ku_0^2}, \ a = \frac{a'\nu}{u_0^2}, \ K = \frac{\nu K_l}{u_0^2} \end{aligned} \tag{8}$$

we get the following governing equations which are dimensionless.

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

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

$$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} - KC \tag{11}$$

The initial and boundary conditions in dimensionless form are as follows:

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

The appeared physical parameters are defined in the nomenclature. The dimensionless governing equations from (9) to (11), with respect to the initial and boundary conditions (12) are solved by usual Laplace transform technique and the solutions are derived for temperature, concentration and velocity fields as follows in terms of exponential and complementary error functions.

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

$$
C(y,t)=\left[\left(\frac{t}{2}+\frac{y\sqrt{Sc}}{4\sqrt{K}}\right)\exp\left(y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{Kt}\right)+\left(\frac{t}{2}-\frac{y\sqrt{Sc}}{4\sqrt{K}}\right)\exp\left(-y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{Kt}\right)\right] \tag{14}
$$

$$
\begin{aligned}
u(y,t)=&\frac{1}{2}\exp(at)\left[\exp\left(y\sqrt{M+a}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{(M+a)t}\right)+\exp\left(-y\sqrt{M+a}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{(M+a)t}\right)\right]\\
&+\frac{b\exp(ct)}{2c^2}\left[\exp\left(y\sqrt{M+c}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{(M+c)t}\right)+\exp\left(-y\sqrt{M+c}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{(M+c)t}\right)\right]\\
&+\frac{d\exp(et)}{2e^2}\left[\exp\left(y\sqrt{M+e}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{(M+e)t}\right)+\exp\left(-y\sqrt{M+e}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{(M+e)t}\right)\right]\\
&-\left(\frac{b}{2c^2}+\frac{d}{2e^2}\right)\left[\exp\left(y\sqrt{M}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{Mt}\right)+\exp\left(-y\sqrt{M}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{Mt}\right)\right]\\
&-\left(\frac{b}{c}+\frac{d}{e}\right)\left[\left(\frac{t}{2}+\frac{y}{4\sqrt{M}}\right)\exp\left(y\sqrt{M}\right)erfc\left(\frac{y}{2\sqrt{t}}+\sqrt{Mt}\right)+\left(\frac{t}{2}-\frac{y}{4\sqrt{M}}\right)\exp\left(-y\sqrt{M}\right)erfc\left(\frac{y}{2\sqrt{t}}-\sqrt{Mt}\right)\right]\\
&-\frac{b\exp(ct)}{2c^2}\left[\exp\left(y\sqrt{R+cPr}\right)erfc\left(\frac{y\sqrt{Pr}}{2\sqrt{t}}+\sqrt{\left(\frac{R}{Pr}+c\right)t}\right)+\exp\left(-y\sqrt{R+cPr}\right)erfc\left(\frac{y\sqrt{Pr}}{2\sqrt{t}}-\sqrt{\left(\frac{R}{Pr}+c\right)t}\right)\right]\\
&+\frac{b}{2c^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]\\
&+\frac{b}{c}\left[\left(\frac{t}{2}+\frac{yPr}{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{yPr}{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]\\
&-\frac{d\exp(et)}{2e^2}\left[\exp\left(y\sqrt{(K+e)Sc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{(K+e)t}\right)+\exp\left(-y\sqrt{(K+e)Sc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{(K+e)t}\right)\right]\\
&+\frac{d}{2e^2}\left[\exp\left(y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{Kt}\right)+\exp\left(-y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{Kt}\right)\right]\\
&+\frac{d}{e}\left[\left(\frac{t}{2}+\frac{y\sqrt{Sc}}{4\sqrt{K}}\right)\exp\left(y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}+\sqrt{Kt}\right)+\left(\frac{t}{2}-\frac{y\sqrt{Sc}}{4\sqrt{K}}\right)\exp\left(-y\sqrt{KSc}\right)erfc\left(\frac{y\sqrt{Sc}}{2\sqrt{t}}-\sqrt{Kt}\right)\right]
\end{aligned}
\tag{15}
$$

where: $b=\frac{Gr}{Pr-1}, c=\frac{M-R}{Pr-1}, d=\frac{Gm}{Sc-1}, e=\frac{M-KSc}{Sc-1}$

THE RATE OF HEAT TRANSFER

Form temperature field, now we study the rate of heat transfer which is given in non-dimensional form as:

$$
Nu=-\left[\frac{d\theta}{dy}\right]_{y=0} \tag{16}
$$

Form equations (13) and (16), we get:

$$Nu = \left[t\sqrt{R}erf\left(\frac{Rt}{Pr}\right) + \sqrt{\frac{tPr}{\pi}}exp\left(-\frac{Rt}{Pr}\right) + \frac{Pr}{2\sqrt{R}}erf\left(\sqrt{\frac{Rt}{Pr}}\right)\right] \quad (17)$$

THE RATE OF MASS TRANSFER

From concentration field, now study the rate of mass transfer which is given in non-dimensional form as

$$Sc = -\left[\frac{dC}{dy}\right]_{y=0} \quad (18)$$

From equations (14) and (18), we get:

$$Sh = t\sqrt{KSc}\,erf\left(\sqrt{Kt}\right) + \sqrt{\frac{tSc}{\pi}}\,exp(-Kt) + \frac{\sqrt{Sc}}{2\sqrt{K}}erf\left(\sqrt{Kt}\right) \quad (19)$$

DISCUSSION AND RESULTS

In order to get physical insight into the problem, we have plotted velocity profiles for different values of the physical parameters a(accelerated parameter), M(magnetic field parameter) R(radiation parameter), Gr(thermal grashof number), Gm(mass grashof number), Pr(prandtl number), Sc(Schmidt number) and t(time) in figures 1(a) to 7 while the chemical reaction parameter (K) is presented in tables 1(a) to2(b) for the cases of cooling (Gr>0,Gm>0) and heating (Gr<0,Gm<0) of the plate. The heating and cooling take place by setting up free convection current due to temperature gradient. The value of Sc (Schmidt number) is taken to be 0.6 which corresponds to the water-vapor. Also, the value of Pr (prandtl number) are chosen such that they represent air (Pr=0.71).

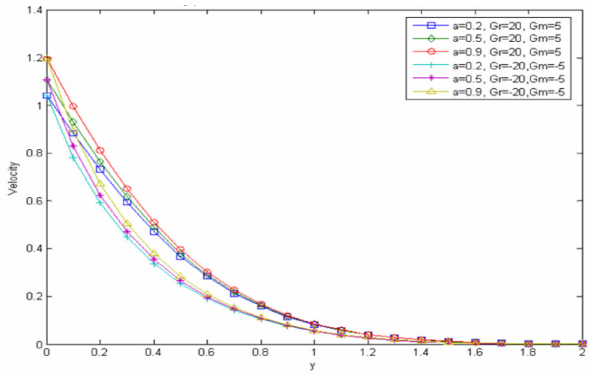

Figure 1(a): Velocity profiles when Sc=0.60, Pr=0.71, M=4, R=10, K=5 and t=0.2

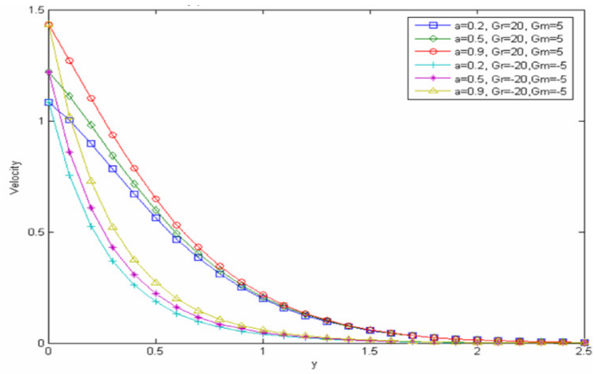

Figure 1(b): Velocity profiles when Sc=0.60, Pr=0.71, M=4, R=10, K=5, and t=0.4

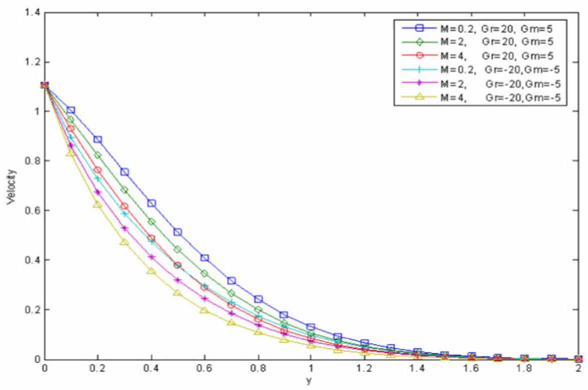

Figure 2(a): Velocity profiles when Sc=0.60, Pr=0.71, R=10, a=0.5, K=5 and t=0.2

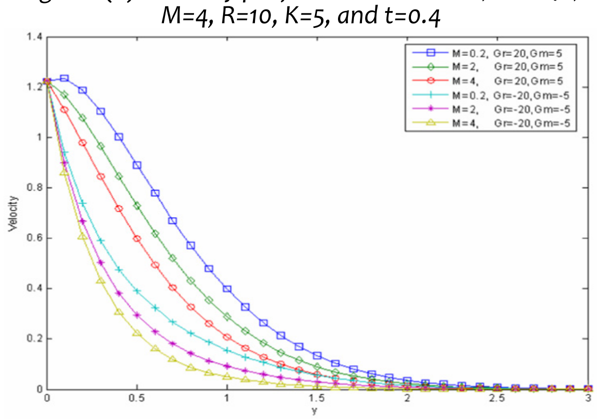

Figure 2(b): Velocity profiles when Sc=0.60, Pr=0.71, R=10, a=0.5, K=5 and t=0.4

The velocity profiles for different values of accelerated parameter (a=0.2, 0.5, 0.9) at time t=0.2 & 0.4 are exhibited through figures 1(a) and 1(b) respectively for the cases of cooling and heating of the surface. It is observed that the velocity increases with an increase in 'a'in both cases of cooling and heating of the plate. Figure 2(a) & 2(b) illustrate the influences of M(magnetic field parameter) on the velocity field in cases of cooling and heating of the plate at time t=0.2&0.4 respectively. It is found that with the increase of magnetic field parameter the velocity decreases for cooling and heating of the plate. Magnetic field lines act as a string to retard the motion of the fluid on free convection flow as the consequence the rate of heat transfer increases.

From Fig. 3(a)-5 it is observed that with increase of R (radiation parameter), Pr (prandtl number) and Sc(Schmidt number) the velocity decreases in the case of cooling of the plate but a reverse effect is noticed in the case of heating of the plate. Physically, it meets the logic that, the fluids with high prandtl number have high viscosity and hence move slowly.

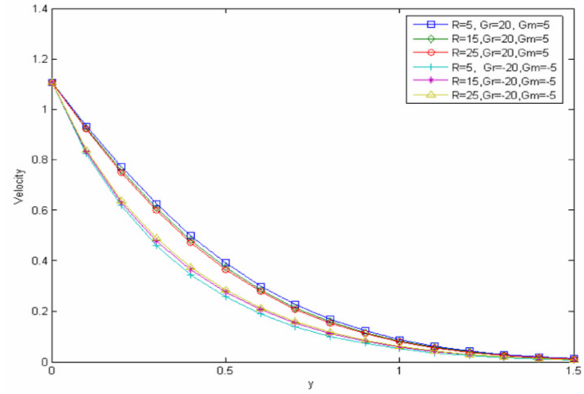

Figure 3(a): Velocity profiles when Sc=0.60, Pr=0.71, M=4, a=0.5, K=5 and t=0.2

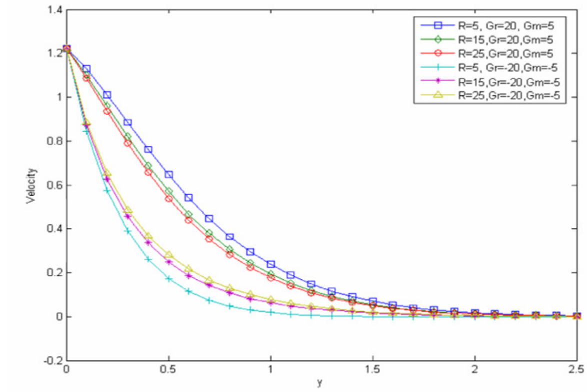

Figure 3(b): Velocity profiles when Sc=0.60, Pr=0.71, M=4, a=0.5, K=5 and t=0.4

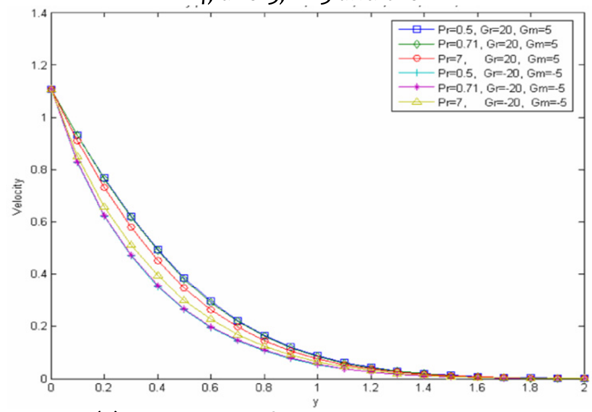

Figure 4(a): Velocity profiles when Sc=0.60, R=10, M=4, a=0.5, K=5 and t=0.2

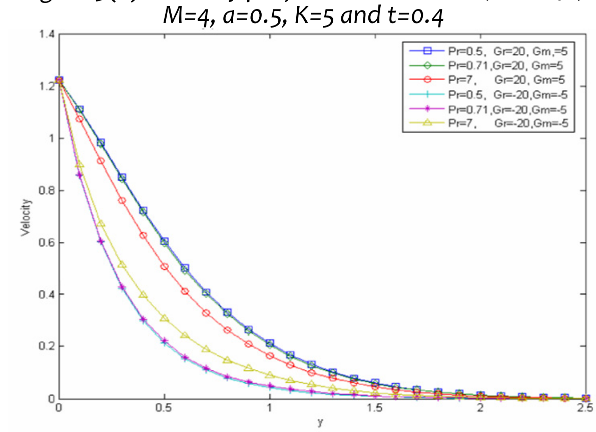

Figure 4(b): Velocity profiles when Sc=0.60, R=10, M=4, a=0.5, K=5 and t=0.4

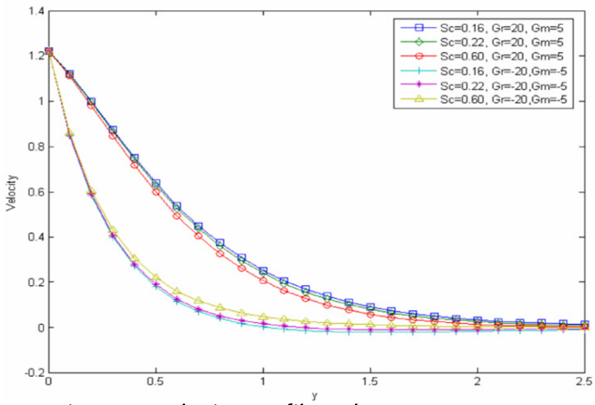

Figure 5: Velocity profiles when Pr=0.71, R=10, M=4, a=0.5, K=5 and t=0.4

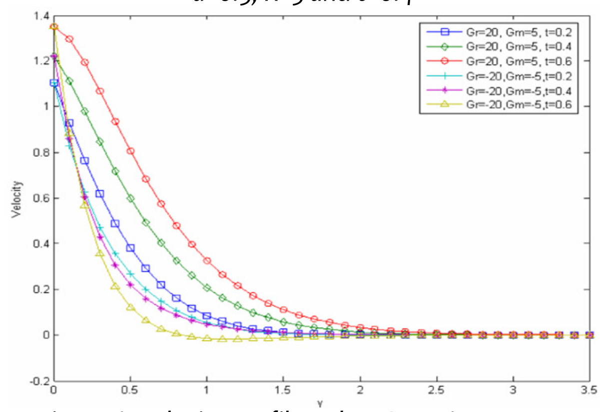

Figure 6: Velocity profiles when Sc=0.60, Pr=0.71, R=10, M=4, a=0.5, K=5

Figure 6 represents the velocity profiles for various values of t (time) in cases of cooling and heating of the surface. It is found that the velocity increases as time t increases in the case of cooling of the plate and an opposite phenomenon is observed in the case of heating of the plate.

Figure 7 reveals that the velocity variations with Gr (thermal grashof number) and Gm (mass grashof number) for the cases of cooling and heating of the plate. It is seen that the velocity increases with an increase in Gr (thermal grashof number) or Gm (mass grashof number) in the case of cooling of the plate. But a reverse effect is identified in the case of heating of the plate. The effect of velocity for different values of K (chemical reaction parameter) are presented in Tables 1(a)-2(b) at time t=0.2&0.4 respectively in cases of cooling and heating of the plate. It is observed that the increase in chemical reaction parameter leads to fall in velocity in the case of cooling of the plate. And the trend is just reversed in the case of heating of the plate.

Table 1(a): Velocity profiles when Sc=0.6, Pr=0.71, M=4, R=10, a=0.5, Gr=20, Gm=5,t=0.2

y	K=5	K=10	K=15	K=20
0	1.1052	1.1052	1.1052	1.1052
0.2	0.7649	0.7632	0.7619	0.7607
0.4	0.4890	0.4866	0.4848	0.4834
0.6	0.2915	0.2893	0.2877	0.2864
0.8	0.1622	0.1606	0.1594	0.1585
1.0	0.0842	0.0831	0.0824	0.0818
1.2	0.0406	0.0400	0.0396	0.0393
1.4	0.0182	0.0178	0.0176	0.0175
1.6	0.0075	0.0073	0.0072	0.0072
1.8	0.0029	0.0028	0.0027	0.0027
2.0	0.0010	0.0010	0.0010	0.0009

Table 1(b): Velocity profiles when Sc=0.6, Pr=0.71, M=4, R=10, a=0.5, Gr=-20, Gm=-5, t=0.2

y	K=5	K=10	K=15	K=20
0	1.1052	1.1052	1.1052	1.1052
0.2	0.6250	0.6267	0.6280	0.6292
0.4	0.3558	0.3581	0.3600	0.3614
0.6	0.1995	0.2016	0.2033	0.2045
0.8	0.1078	0.1094	0.1106	0.1115
1.0	0.0552	0.0563	0.0570	0.0576
1.2	0.0264	0.0270	0.0275	0.0278
1.4	0.0117	0.0120	0.0123	0.0124
1.6	0.0047	0.0049	0.0050	0.0051
1.8	0.0018	0.0018	0.0019	0.0019
2.0	0.0006	0.0006	0.0006	0.0007

Table 2(a): Velocity profiles when Sc=0.6, Pr=0.71, M=4, R=10, a=0.5, Gr=20, Gm=5, t=0.4

y	K=5	K=10	K=15	K=20
0	1.2214	1.2214	1.2214	1.2214
0.2	0.9799	0.9730	0.9681	0.9645
0.4	0.7164	0.7057	0.6984	0.6931
0.6	0.4938	0.4823	0.4748	0.4697
0.8	0.3258	0.3155	0.3091	0.3048
1.0	0.2073	0.1989	0.1940	0.1909
1.2	0.1277	0.1214	0.1179	0.1157
1.4	0.0762	0.0718	0.0694	0.0680
1.6	0.0441	0.0411	0.0396	0.0387
1.8	0.0247	0.0228	0.0219	0.0213
2.0	0.0134	0.0122	0.0117	0.0114

Table 2(b): Velocity profiles when Sc=0.6, Pr=0.71, M=4, R=10, a=0.5, Gr=-20, Gm=-5, t=0.4

y	K=5	K=10	K=15	K=20
0	1.2214	1.2214	1.2214	1.2214
0.2	0.6064	0.6133	0.6182	0.6218
0.4	0.3068	0.3175	0.3247	0.3300
0.6	0.1597	0.1712	0.1786	0.1838
0.8	0.0860	0.0964	0.1028	0.1070
1.0	0.0478	0.0562	0.0612	0.0643
1.2	0.0272	0.0335	0.0370	0.0391
1.4	0.0155	0.0199	0.0223	0.0237
1.6	0.0087	0.0117	0.0132	0.0141
1.8	0.0048	0.0067	0.0076	0.0082
2.0	0.0025	0.0037	0.0043	0.0046

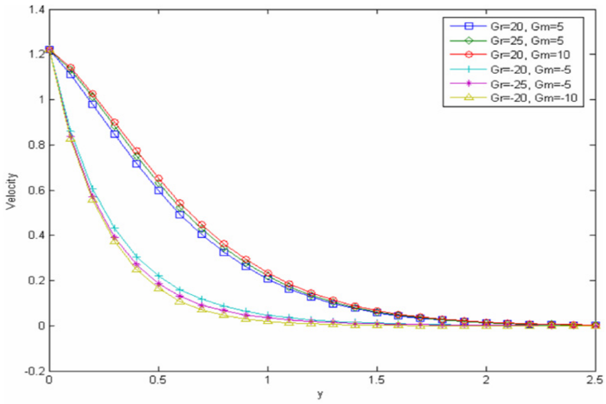

Figure 7: Velocity profiles when Sc=0.60, Pr=0.71, R=10, M=4, a=0.5, K=5, t=0.4

The effects of radiation parameter (R) on the temperature profiles are shown in Fig (8). For large values R, it is pointed out that the temperature decreases more rapidly with the increase of R. Therefore, using radiation we can control the temperature distribution and flow transport. The effect of concentration profiles for different values of chemical reaction parameter (K=2, 5 &10) at time t=0.2 &0.4 are presented in figure 9. It is observed that the concentration increases with decreasing chemical reaction parameter (K) and from figure 10 it is seen that the concentration increases with an increase in time t.

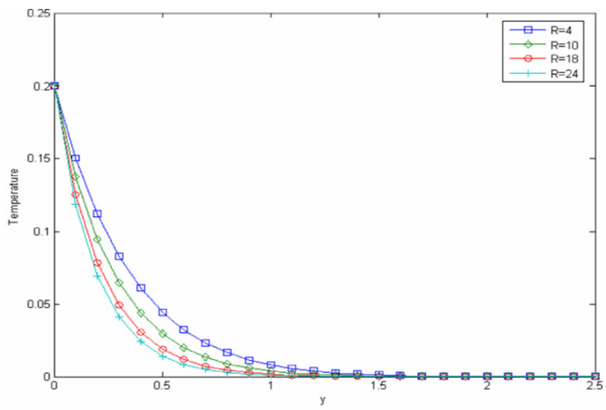

Figure 8: Temperature profiles for different R

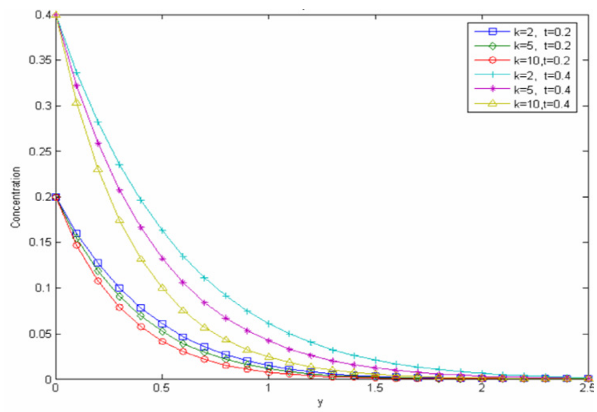

Figure 9: Concentration profiles for different K

Figure 11 demonstrates the effect of Schmidt number (Sc) on the concentration field at time t=0.2 &0.4. It is found that the concentration decreases with an increase in Sc. And it is interesting to note that, concentration decreases slowly for Sc=0.22 (hydrogen) in comparison of other gases Sc=0.60 (water-vapor) and Sc=0.78 (ammonia).

It is obviously seen that from figure 12 Nusselt number is observed to increase with increase in R for both water (Pr = 7) and air (Pr = 0.71). It is also observed that Nusselt number for water (Pr = 7) is *higher than that of air (Pr = 0.71). The reason is that the 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. Finally, from figure 13 it observed that Sherwood number increases as Schmidt parameter (Sc) or Chemical reaction parameter (K) increases.*

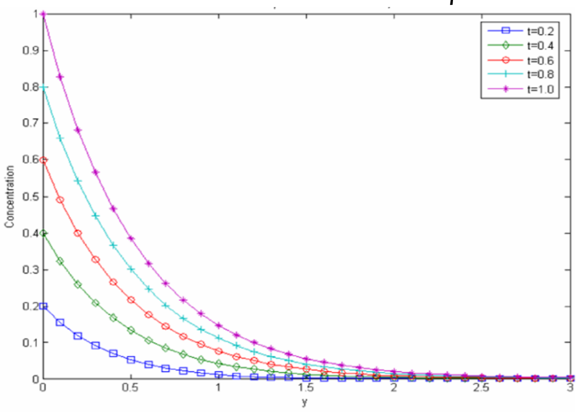

Figure 10: Concentration profiles for different t

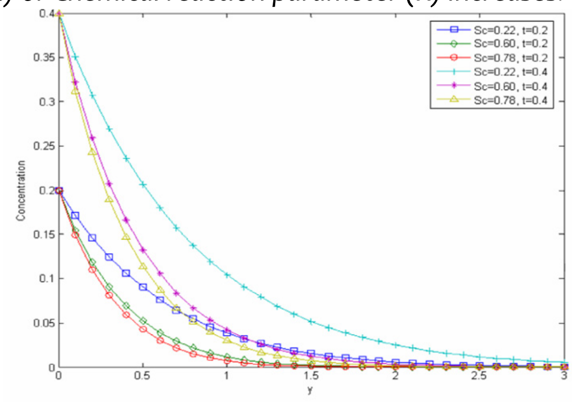

Figure 11: Concentration profiles for different Sc

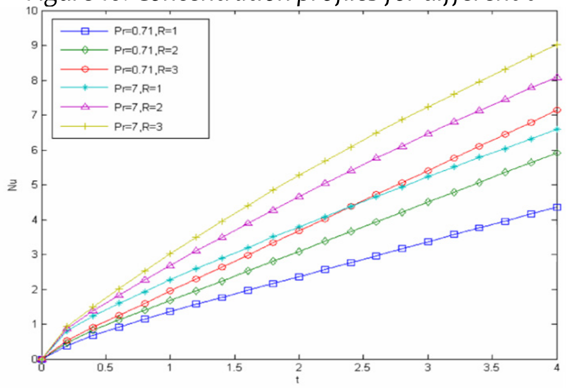

Figure 12: Nusselt number

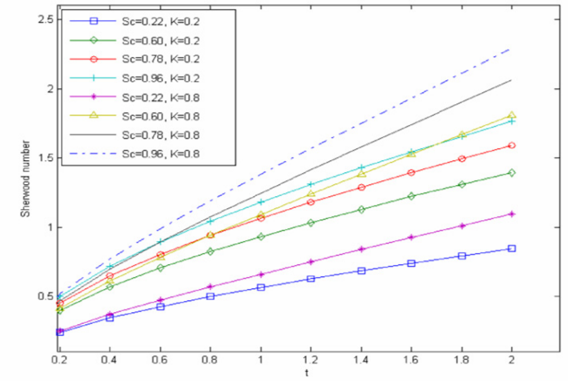

Figure 13: Sherwood number

SUMMARY

An analytical study is performed to investigate the effects of chemical reaction and radiation on unsteady MHD flow past an exponentially accelerated vertical plate with variable temperature and variable mass diffusion in the presence of applied transverse magnetic field. It is assumed that the effect of viscous dissipation is negligible in the energy equation and there is a first order chemical reaction between the diffusing species and the fluid. The flow is assumed to be in x' - direction which is taken along the infinite vertical plate in the upward direction and y' - axis is taken normal to the plate. At time t' > 0, the both temperature and species concentration levels near the plate are raised linearly with time time t. A general exact solution of the governing partial differential equations is obtained by usual Laplace transform technique. The velocity, temperature and concentration fields are studied for different physical parameters like thermal Grashof number (Gr), mass Grashof number (Gm), Schmidt number (Sc), Prndtl number (Pr), radiation parameter (R), magnetic field parameter (M), accelerated parameter (a) and time (t) graphically while the effect of chemical reaction parameter (K) is presented through tables.

NOMENCLATURE

a^* - Absorption coefficient
a - Accelerated parameter
B_0 - External magnetic field
C' - Species concentration
C'_w - Concentration of the plate
C'_∞ - Concentration of fluid far away from the plate
C - Dimensionless concentration
C_p - Specific heat at constant pressure.
g - Acceleration due to gravity.
Gr - Thermal Grashof number
Gm - Mass Grashof number
M - Magnetic field parameter
Nu - Nusselt number
Pr - Prandtl number
Gr - Radiative heat flux in the y – direction
R - Radiative parameter
Sc - Schmidt number
K - Chemical reaction parameter
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:

α - Thermal diffusivity
β - Volumetric Coefficient of thermal expansion
β - Volumetric Coefficient of expansion with concentration*
μ - Coefficient of viscosity
k - Thermal conductivity of the fluid
ν - Kinematic viscosity
ρ - Density of the fluid
τ - Electric conductivity
ϑ - Dimensionless temperature
erf - Error function
erfc - Complementary error function

Subscripts:

w - Conditions on the wall
∞ - Free stream conditions

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