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MHD MASS TRANSFER FLOW PAST A VERTICAL POROUS PLATE EMBEDDED IN A POROUS MEDIUM IN A SLIP FLOW REGIME WITH THE INFLUENCE OF HALL CURRENT AND THERMAL DIFFUSION

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ABSTRACT

The objective of this paper is to analyze the effects of hall current and thermal diffusion on MHD unsteady mass transfer flow past a semi-infinite vertical porous plate embedded in a porous medium in a slip flow regime in presences of variable suction, thermal radiation and chemical reaction. The analysis has been made by assuming that the fluid is viscous, incompressible, electrically conducting, heat absorbing and laminar flow. A magnetic field of uniform strength is assumed to be applied transversely to the direction of the main flow. Perturbation technique is applied to transform the non-linear coupled governing partial differential equations in dimensionless form into a system of ordinary differential equations. The governing equations of the problem subject to the slip flow boundary conditions are solved analytically and solutions for velocity, temperature and concentration field are obtained. The effects of various parameters such as Grashof number for heat transfer (Gr), Grashof number for mass transfer (Gm), Magnetic Parameter (M), Hall parameter (m), Heat Source Parameter (Q), Radiation Parameter (R), Chemical reaction Parameter (K), Rarefaction Parameter (h), Schmidt number (Sc), Soret number (Sr) on velocity field, temperature distribution and concentration distribution are presented graphically.

Key words: Porous Medium; Slip Flow; Rarefaction; Viscous Drag; Free Convection; Mass transfer; Hall Effect.

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INTRODUCTION

In recent years, the analysis of hydromagnetic flow involving heat and mass transfer in porous medium has attracted the attention of many scholars because of its possible applications in diverse fields of science and technology such as –soil sciences, astrophysics, geophysics, nuclear power reactors etc. The Magneto hydrodynamics in the present form is due to the contributions of several notable authors like Shercliff (1965), Ferraro and Plumpton (1966) and Cramer and Pai (1973). Thermal radiation in free convection has also been studied by many authors because of its applications in many engineering and industrial processes. Examples include nuclear power plant, solar power technology, steel industry, fossil fuel combustion, space sciences applications, etc. In many chemical engineering processes, there does occur the chemical reaction between a foreign mass and the fluid in which the plate is moving. These processes take place in numerous industrial applications, namely polymer production, manufacturing of ceramics or glassware, and food procession.

The effect of chemical reaction on an unsteady MHD free convection flow past an infinite vertical porous plate with variable suction was studied by K. Sarada and B. Shanker[5]. Theoretical analysis was carried out to study the effect of chemical reaction and radiation absorption on MHD convective heat and mass transfer flow past a semi-infinite vertical moving plate with time dependent suction by H. Singh, P. Ram and A. Kumar[4]. Mamta Goyal and Kiran Kumari[7] investigated theoretical study of heat and mass transfer in MHD oscillatory flow between two inclined porous plates with radiation absorption and chemical reaction. R. Panneerselvi and J. Kowsalya made an analysis of ion slip and dufour effect on unsteady free convection flow past an infinite vertical plate with oscillatory suction velocity and variable permeability. An analytical study of MHD free convective, dissipative boundary layer flow past a porous vertical surface in the presence of thermal radiation, chemical reaction and constant suction was done by M.C. Raju et al.[9]. Seethamahalakshmi et al.[20] investigated the effects of the chemical reaction and radiation absorption on an unsteady MHD convective heat and mass transfer flow past a semi-infinite vertical plate in a porous medium with heat source and suction. T.Poornima and N. Bhaskar Reddy[22] has studied the effects of thermal radiation and chemical reaction on MHD free convective flow past a semi-infinite vertical porous moving plate. Radiation and chemical reaction effects on an unsteady MHD convection flow past a vertical moving porous plate embedded in a porous medium with viscous dissipation was studied by M. Sudheer Babu et al.[11].

In all these investigations “no-slip” boundary condition is considered for the velocity field. However, in some application e.g. in microfluidic and nanofluidic devices where the surface to volume ratio is large, the slip behavior is more typical and slip boundary condition is usually used for the velocity field (Darhuber and Troian, 2005) which was first proposed by Navier in the year 1823. Nazibuddin Ahmed and Kishor Kumar Das[13] discussed MHD mass transfer flow past a vertical porous plate embedded in a porous medium in a slip flow regime with thermal radiation and chemical reaction. In the above mentioned studies, the thermal diffusion (soret) effect was not taken into account in the species continuity equation and the Hall effect term was ignored in applying ohm’s law as it has no marked effect for small and moderate values of the magnetic field. It was considered that, the mass transfer occurs due to concentration gradients alone. However, in presence of high temperature gradient, species transportation may also take place. The process of mass transfer that occurs by the combine effects of concentration as well as temperature gradients is known as thermal diffusion or soret effect. For moderate or high concentration of species, the soret effect is significant and cannot be ignored. The experimental investigation of the thermal diffusion effect on mass transfer related problems was first performed by Charles soret in 1879. The benchmark contribution in soret effect was made by Eckert and Drake (Eckert and Drake 1972). The current trend for the application of magneto hydrodynamics is towards a strong magnetic field. Under these conditions, the Hall current is important and it has a marked effect on the magnitude and direction of the current density and consequently on the magnetic force term. Hall effects are used as a direct replacement for the mechanical breaker points used in earlier automotive applications in automotive ignition and fuel injection. The study of hydromagnetic viscous flows with Hall currents has important engineering applications in problems of magneto hydrodynamic generators and of Hall accelerators as well as in flight magneto hydrodynamics.

B. Lavanya and A. Leela Ratnam[1] considered radiation and mass transfer effects on unsteady MHD free convective flow past a vertical porous plate embedded in a porous medium in a slip flow regime with heat source/sink and soret effect. Unsteady MHD free convective heat and mass transfer flow past a semi-infinite vertical permeable moving plate with heat absorption, radiation, chemical reaction and soret effects was studied by B. Madhusudhana Rao et al.[2]. G. V. Ramana Reddy et al.[3] investigated unsteady MHD free convective mass transfer flow past an infinite vertical porous plate with variable suction and soret effect. K.V.S.Raju et al.[6] discussed unsteady MHD thermal diffusive, radiative and free convective flow past a vertical porous plate through non-homogeneous porous medium. Soret and dufour effects on steady MHD free convection flow past a semi-infinite moving vertical plate in a porous medium with viscous dissipation have been investigated by M. Gnaneswara Reddy and N. Bhaskar Reddy[8]. M. S. Hossain et al. [10] considered study of unsteady MHD free convection flow past a vertical plate with thermal diffusion and chemical reaction. Diffusion-Thermo effects on MHD flow past an infinite vertical porous plate in the presence of radiation and chemical reaction was studied by M. Venkateswarlu et al.[12].

S. P. Anjali Devi and J. Wilfred Samuel Raj[17] considered thermodiffusion effects on unsteady hydromagnetic free convection flow with heat and mass transfer past a moving vertical plate with time dependent suction and heat source in a slip flow regime. MHD transient flow with hall current past an accelerated horizontal porous plate in a rotating system have been investigated by Nazibuddin Ahmed et al.[14]. S. Das, S. K. Guchhait and R. N. Jana[21] considered hall effects on unsteady hydromagnetic flow past an accelerated porous plate in a rotating system. In view of the significance of the thermal diffusion as well as hall effect, the present work is concerned with the study of MHD mass transfer flow past a vertical porous plate embedded in a porous medium in a slip flow regime with the influence of hall current and thermal diffusion.

2.MATHEMATICAL FORMULATION

Consider a two dimensional unsteady flow of a laminar, viscous, incompressible, electrically conducting and heat absorbing fluid through porous medium past a semi-infinite vertical porous plate embedded in a slip flow regime in presences of thermal radiation, chemical reaction, hall current and thermal diffusion. Let the x-axis be taken along the plate in the direction of the flow and y-axis perpendicular to the plate and directed in the fluid region and z axis along the width of the plate. A uniform magnetic field of strength B_0 in the presence of radiation is imposed transversely in the direction of y-axis. The induced magnetic field is neglected under the assumption that the magnetic Reynolds number is small. It is assumed that there is no applied voltage which implies the absence of any electrical field. The radiative heat flux in the x-direction is considered negligible in comparison to that in y-direction. The governing equations for this study are based on the conservation of mass, linear momentum, energy and species concentration. Taking in to consideration the assumptions made above, these equations in Cartesian frame of reference are given by:

Equation of Continuity:

$$\frac{\partial V'}{\partial y'} = 0 \tag{1}$$

That is $$V' = -V_0\,(1+\varepsilon A e^{n^* t^*}) \tag{2}$$

Equation of Momentum:

$$\frac{\partial u'}{\partial t'} + V'\frac{\partial u'}{\partial y'} = -\frac{1}{\rho}\frac{\partial p'}{\partial x'} + g\beta(T' - T'_\infty) + g\beta'(C' - C'_\infty) + \upsilon\,\frac{\partial^2 u'}{\partial y'^2} - \frac{\sigma B_0^2}{\rho(1+m^2)}u' - \frac{\upsilon}{K'}u' \tag{3}$$

Equation of Energy:

$$\frac{\partial T'}{\partial t'} + V'\frac{\partial T'}{\partial y'} = \frac{K}{\rho C_p}\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho C_p}\frac{\partial q_r^*}{\partial y'} + \frac{Q_0(T'_\infty - T')}{\rho C_p} \tag{4}$$

On disregarding Joule's heating.

Equation of Concentration:

$$\frac{\partial C'}{\partial t'} + V'\frac{\partial C'}{\partial y'} = D_m\frac{\partial^2 C'}{\partial y'^2} + K'(C'_\infty - C') + \frac{D_m K_T}{T_m}\frac{\partial^2 T'}{\partial y'^2} \tag{5}$$

Cogley *et al*. [23] showed that, in the optically thin limit for a non-gray gas near equilibrium, the radiative heat flux is represented by the following form:

$\frac{\partial q_r^*}{\partial \bar{y}} = 4(\bar{T} - \bar{T}_\infty)I^*$,where $I^* = \int K_{\rho w}\frac{\partial e_{b\rho}}{\partial \bar{T}}d\rho$, $K_{\rho w}$ is the absorption coefficient at the wall and $e_{b\rho}$ is the Planck's function. Under the assumption, the appropriate boundary conditions for velocity involving slip flow are given by

$$\left.\begin{aligned} u' = u'_{slip} &= h'\frac{\partial u'}{\partial y'},\ V' = -V_0(1+\varepsilon A e^{n^* t^*}) \\ T' &= T'_w + \varepsilon(T'_w - T'_\infty)e^{n^* t^*}, \\ C' &= C'_w + \varepsilon(C'_w - C'_\infty)e^{n^* t^*} \end{aligned}\right\} \text{at } y' \to 0$$

$$\left.\begin{array}{l} u' \to U'_\infty = U_0(1+\varepsilon e^{n^*t^*}),\\ \qquad T' \to T'_\infty,\\ \qquad C' \to C'_\infty \end{array}\right\} \quad \text{as } y'\to\infty \tag{6}$$

Consider the following non dimensional parameters

$$y=\frac{y'V_0}{\upsilon},\; t=\frac{t'V_0^2}{\upsilon},\; u=\frac{u'}{U_0},\; U_\infty=\frac{U'_\infty}{U_0},\; n=\frac{n^*\upsilon}{V_0^2}$$

$$\upsilon=\frac{\mu}{\rho},\; v=\frac{V'}{V_0},\; \theta=\left(\frac{T'-T'_\infty}{T'_w-T'_\infty}\right),\; \emptyset=\left(\frac{C'-C'_\infty}{C'_w-C'_\infty}\right) \tag{7}$$

By introducing the non-dimensional parameters into Eqs. (2)−(5) it reduces to

$$\frac{\partial u}{\partial t}-(1+\varepsilon A e^{nt})\frac{\partial u}{\partial y}=\frac{dU_\infty}{dt}+\frac{\partial^2 u}{\partial y^2}+Gr\theta+Gm\emptyset+-N(U_\infty-u) \tag{8}$$

$$\frac{\partial \theta}{\partial t}-(1+\varepsilon A e^{nt})\frac{\partial \theta}{\partial y}=\frac{1}{Pr}\frac{\partial^2 \theta}{\partial y^2}-R\theta-Q\theta \tag{9}$$

$$\frac{\partial \emptyset}{\partial t}-(1+\varepsilon A e^{nt})\frac{\partial \emptyset}{\partial y}=\frac{1}{Sc}\frac{\partial^2 \emptyset}{\partial y^2}-K\emptyset+Sr\frac{\partial^2 \theta}{\partial y^2} \tag{10}$$

where $M_1=\frac{M}{(1+m^2)}$ and $N=M_1+\frac{1}{\alpha}$

$Pr=\frac{\mu C_p}{K}$: Prandtl number

$Gr=\frac{\upsilon g\beta(T'_w-T'_\infty)}{U_0V_0^2}$: Grashof number

$Gm=\frac{\upsilon g\beta(C'_w-C'_\infty)}{U_0V_0^2}$: Modified Grashof number

$M=\left(\frac{\sigma B_0^2}{\rho}\right)\frac{\upsilon}{V_0^2}$: Magnetic Parameter

$m=\omega\tau$: Hall parameter

$\alpha=\frac{k^*V_0^2}{\upsilon^2}$: Permeability Parameter

$Q=\frac{Q_0\upsilon}{\rho C_pV_0^2}$: Heat Source Parameter

$R=\frac{4\upsilon I^*}{\rho C_pV_0^2}$: Radiation Parameter

$K=\frac{k'\upsilon}{V_0^2}$: Chemical reaction Parameter

$h=\frac{v_0\,h'}{\upsilon}$: Rarefaction Parameter

Sc = $\frac{\nu}{D_m}$: Schmidt number

Sr = $\frac{D_m K_T}{T_m \nu}\ \frac{(T_w^{'}-T_\infty^{'})}{(C_w^{'}-C_\infty^{'})}$: Soret number

the modified boundary conditions are

$$\left.\begin{aligned} &u = \text{uslip} = h\,\frac{\partial u}{\partial y},\ \theta = 1+\varepsilon e^{nt},\ \emptyset = 1+\varepsilon e^{nt} \quad \text{at} \quad y = 0 \quad \text{and} \\ &u \to U_\infty = 1+\varepsilon e^{nt},\ \theta \to 0,\ \emptyset \to 0 \qquad\qquad \text{as} \quad y \to \infty \end{aligned}\right\} \tag{11}$$

To solve Eqs.(8), (9) and (10) we assume from V.M.Soundalgekar, J.P.Bhat (1984) that

$$u(y,t) = u_0(y) + \varepsilon e^{nt}\, u_1(y) \tag{12}$$

$$\theta(y,t) = \theta_0(y) + \varepsilon e^{nt}\, \theta_1(y) \tag{13}$$

$$\emptyset(y,t) = \emptyset_0(y) + \varepsilon e^{nt}\, \emptyset_1(y) \tag{14}$$

Substituting Eqs.(12) - (14) in Eqs.(8) - (10), equating the harmonic and non harmonic terms and neglecting the co-efficient of higher powers of ε we get

$$\frac{\partial^2 u_0}{\partial y^2} + \frac{\partial u_0}{\partial y} - N u_0 = -N - Gr\theta_0 - Gm\emptyset_0 \tag{15}$$

$$\frac{\partial^2 u_1}{\partial y^2} + \frac{\partial u_1}{\partial y} - (N+n)u_1 = -Gr\theta_1 - Gm\emptyset_1 - A\frac{\partial u_0}{\partial y} - (N+n) \tag{16}$$

$$\frac{\partial^2 \theta_0}{\partial y^2} + Pr\frac{\partial \theta_0}{\partial y} - Pr(R+Q)\,\theta_0 = 0 \tag{17}$$

$$\frac{\partial^2 \theta_1}{\partial y^2} + Pr\frac{\partial \theta_1}{\partial y} - \Pr(R+Q+n)\,\theta_1 = -APr\frac{\partial \theta_0}{\partial y} \tag{18}$$

$$\frac{\partial^2 \emptyset_0}{\partial y^2} + Sc\frac{\partial \emptyset_0}{\partial y} - KSc\emptyset_0 = -ScSr\frac{\partial^2 \theta_0}{\partial y^2} \tag{19}$$

$$\frac{\partial^2 \emptyset_1}{\partial y^2} + Sc\frac{\partial \emptyset_1}{\partial y} - Sc(K+n)\emptyset_1 = -ScA\frac{\partial \emptyset_0}{\partial y} - ScSr\frac{\partial^2 \theta_1}{\partial y^2} \tag{20}$$

The corresponding boundary conditions can be written as

$$\left.\begin{aligned} u_0 = hu_0{'},\ u_1 = hu_1{'} \\ \theta_0 = 1,\ \theta_1 = 1 \\ \emptyset_0 = 1,\ \emptyset_1 = 1 \end{aligned}\right\} \quad \text{at } y = 0$$

$$\left.\begin{aligned} u_0 = 1,\ u_1 = 1 \\ \theta_0 \to 0,\ \theta_1 \to 0 \\ \emptyset_0 \to 0,\ \emptyset_1 \to 0 \end{aligned}\right\} \quad \text{as } y \to \infty \tag{21}$$

The solutions of Equations (15) to (20) which satisfy the boundary conditions (21) are given by

$$u_0(y) = 1 + (Y_1 + Y_3)e^{-m_1 y} + Y_2 e^{-m_3 y} + Y_4 e^{-m_5 y} \quad (22)$$

$$u_1(y) = 1 + Y_7 e^{-m_1 y} + Y_8 e^{-m_2 y} + Y_6 e^{-m_3 y} + Y_9 e^{-m_4 y} + Y_5 e^{-m_5 y} + Y_{10} e^{-m_6 y} \quad (23)$$

$$\theta_0(y) = e^{-m_1 y} \quad (24)$$

$$\theta_1(y) = D_1 e^{-m_1 y} + (1 - D_1)e^{-m_2 y} \quad (25)$$

$$\emptyset_0(y) = (1 + D_0)e^{-m_3 y} - D_0 e^{-m_1 y} \quad (26)$$

$$\emptyset_1(y) = X_3 e^{-m_1 y} + X_2 e^{-m_2 y} + X_1 e^{-m_3 y} + (1 - X_4)e^{-m_4 y} \quad (27)$$

where the constants $m_1, m_2, m_3, m_4, m_5, m_6, D_0, D_1, X_1, X_2, X_3, X_4, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6, Y_7, Y_8, Y_9, Y_{10}$ used above are functions of the physical parameters involved in the problem.

Substituting equations (22) to (27) in equations (12) to (14), we obtain the velocity, temperature and concentration distributions in the boundary layer as follows:

$$u(y,t) = 1 + (Y_1 + Y_3)e^{-m_1 y} + Y_2 e^{-m_3 y} + Y_4 e^{-m_5 y} + \varepsilon e^{nt}(1 + Y_7 e^{-m_1 y} + Y_8 e^{-m_2 y} + Y_6 e^{-m_3 y} + Y_9 e^{-m_4 y} + Y_5 e^{-m_5 y} + Y_{10} e^{-m_6 y})$$

$$\theta(y,t) = e^{-m_1 y} + \varepsilon e^{nt}(D_1 e^{-m_1 y} + (1 - D_1)e^{-m_2 y})$$

$$\emptyset(y,t) = (1 + D_0)e^{-m_3 y} - D_0 e^{-m_1 y} + \varepsilon e^{nt}(X_3 e^{-m_1 y} + X_2 e^{-m_2 y} + X_1 e^{-m_3 y} + (1 - X_4)e^{-m_4 y}$$

3. RESULT AND DISCUSSION

The effects of various physical parameters such as Grashof number for heat transfer (Gr), Grashof number for mass transfer (Gm), Magnetic Parameter (M), Hall parameter (m), Heat Source Parameter (Q), Radiation Parameter (R), Chemical reaction Parameter (K), Rarefaction Parameter (h), Schmidt number (Sc), Soret number (Sr) on the velocity profile, temperature profile and concentration profile have been studied analytically. Throughout our investigation the value of Prandtl number Pr is kept constant at 0.71 which corresponding to air at $20^{\circ}C$. The computed results of the analytical solutions are presented in Figs 1- 15.

Fig 1 Exhibits the velocity profile u for various Radiation Parameter (R). It shows that the profile decreases with increases in Radiation Parameter (R).

Fig 2 Clearly shows the velocity profile u for different Magnetic Parameter (M). It illustrates that velocity decreases as the existence of magnetic field becomes stronger.

Fig 3 Illustrates the effect of Chemical reaction (K) on the velocity profile u. It is evident that the velocity profile u increases with the increases of Chemical reaction Parameter (K).

Fig 4 Depicts the velocity profile u for various heat Source Parameter (Q). It observed that, the profile decreases with increases of heat Source Parameter (Q).

Fig 5 Illustrates the effect of Soret number (Sr) on the velocity profile u. It shows that the velocity profile u increases as Soret number (Sr) increases.

Fig 6 Exhibits the velocity profile u for various Schmidt number (Sc). It indicates the fact that increases in Schmidt number (Sc) accelerates the fluid flow.

Fig 7 Clearly shows the velocity profile u for different Rarefaction Parameter (h). It is observed that, the velocity profile u increases as rarefaction parameter (h) is increased indicating the fact that slips at the surface accelerates the fluid motion.

Fig 8 Illustrates the effect of Hall parameter (m) on the velocity profile u. It is evident that, the velocity profile u increases with increases of Hall parameter (m).

Fig 9 Depicts the velocity profile u for various Grashof number for heat transfer (Gr). It is observed that, increases in Grashof number for heat transfer (Gr) leads to a rise in the value of velocity profile u due to enhancement in buoyance force.

Fig 10 Exhibits the velocity profile u for different Grashof number for mass transfer (Gm). It is clear that the velocity u increases for the increasing values of Grashof number for mass transfer (Gm).

Fig 11 Shows the temperature profile θ for different heat Source Parameter (Q). It reveals that the temperature profile θ decreases with increases of heat Source Parameter (Q) and the profile tends to zero as $y \to \infty$.

Fig 12 Illustrates the effect of Radiation Parameter (R) on the temperature profile θ. It is observed that, the temperature profile θ decreases as Radiation Parameter (R) increases.

Fig 13 Exhibits the variation of species concentration profile $\emptyset$ against y under the influence of Schmidt number (Sc). It shows that the concentration profile decreases with increases in Schmidt number (Sc).

Fig 14 Depicts the concentration profile $\emptyset$ for different Soret number (Sr). It observes that the concentration profile increases with the increase of Soret number (Sr).

Fig 15 Illustrates the effect of Chemical reaction (K) on the concentration profile $\emptyset$. It is evident that the concentration profile decreases with increase of Chemical reaction (K).

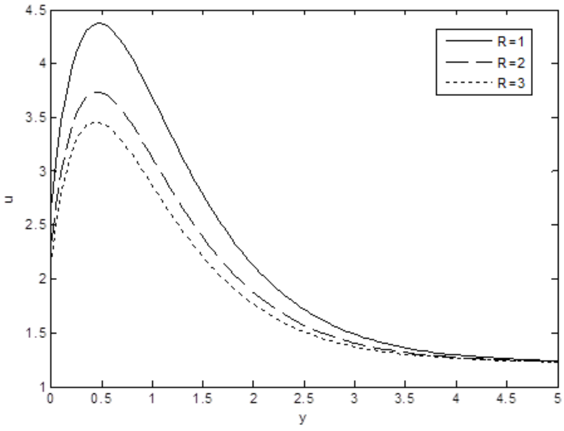

Fig 1. Velocity u versus y, under the effect R, for Gr=1, Pr=0.71, Gm=2, a=1, Q=1, Ec=0.005, h=0.3, e=0.2, Sc=0.6,A=1, K=1,n=0.1,M=0.5, m=0.4,Sr=1.

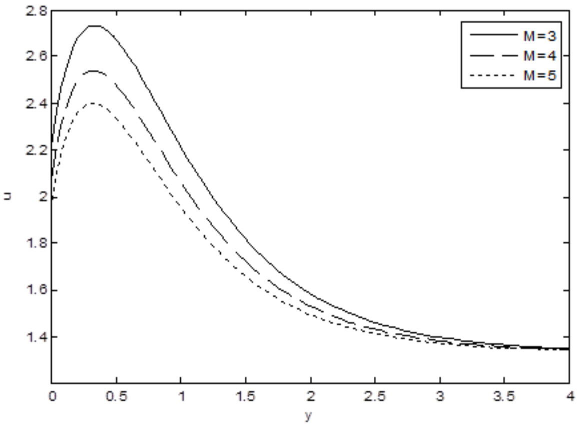

Fig 2. Velocity u versus y, under the effect M, for Gr=6, Pr=0.71, Gm=4, a=1, Q=1, Ec=0.001, h=0.3, e=0.2, Sc=0.6, A=1, K=1, n=0.1, m=0.4, Sr=1, R=1.

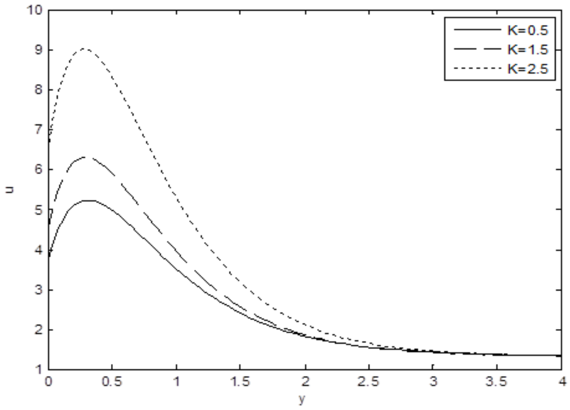

Fig 3. Velocity u versus y, under the effect K , for Gr=6, Pr=0.71, Gm=4, a=1, Q=1, Ec=0.005, h=0.3, e=0.2,Sc=0.6,A=4,n=0.5,m=0.4,Sr=1,R=2,M=3.

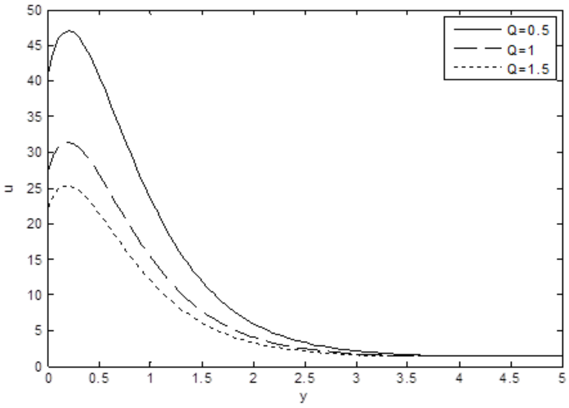

Fig 4. Velocity u versus y, under the effect Q, for Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005,h=0.6, e=0.2, Sc=0.9,A=4,n=0.5,m=0.4,Sr=2,R=2,M=3,K=1.

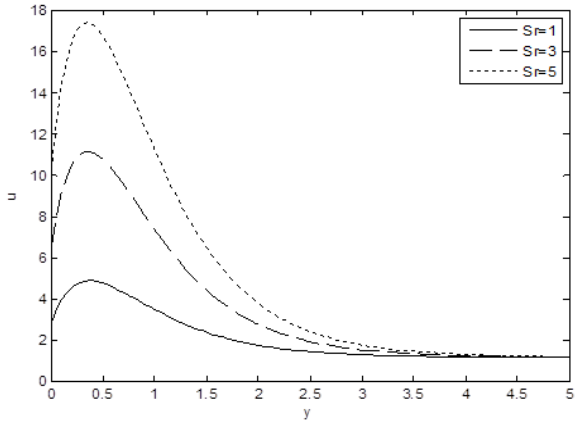

Fig 5. Velocity u versus y, under the effect Sr, for Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005,h=0.2,e=0.1, A=6,n=0.5,m=0.4,R=1,M=3,K=1,Q=1,Sc=0.6.

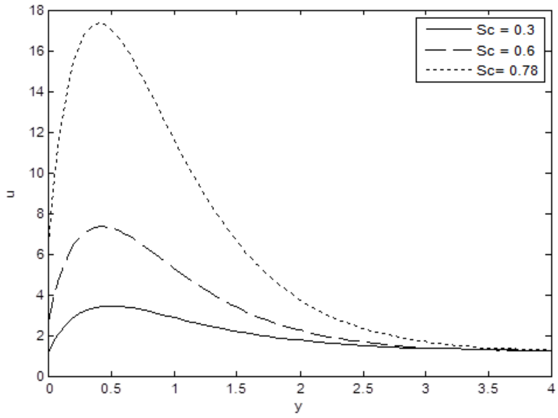

Fig 6. Velocity u versus y, under the effect Sc , for Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005, h=0.1, e=0.1, A=6,n=0.5,m=0.4,Sr=2,R=1,M=3,K=1,Q=1.

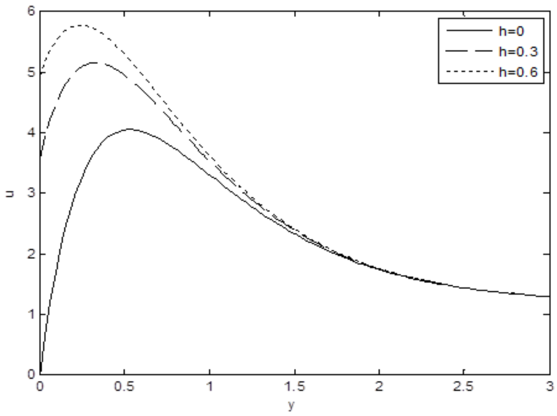

Fig 7. Velocity u versus y, under the effect h, for Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005,e=0.1, A=6, n=0.5,m=0.4,R=1,M=3,K=1,Q=1,Sc=0.6,Sr=1

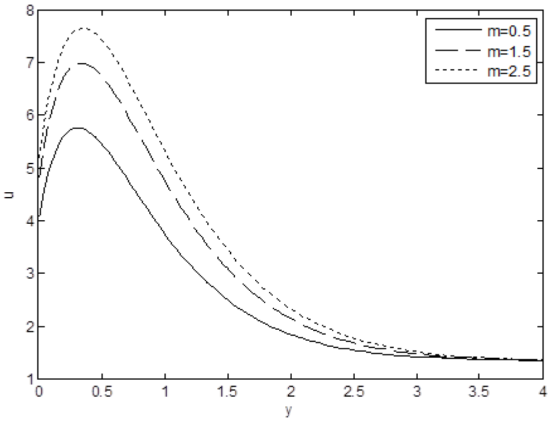

Fig 8. Velocity u versus y, under the effect m, for Gr=6,Pr=0.71,Gm=4,a=1,Q=1,Ec=0.005,h=0.3, e=0.2,Sc=0.6,A=4,n=0.5,Sr=1,R=,M=3,K=1.

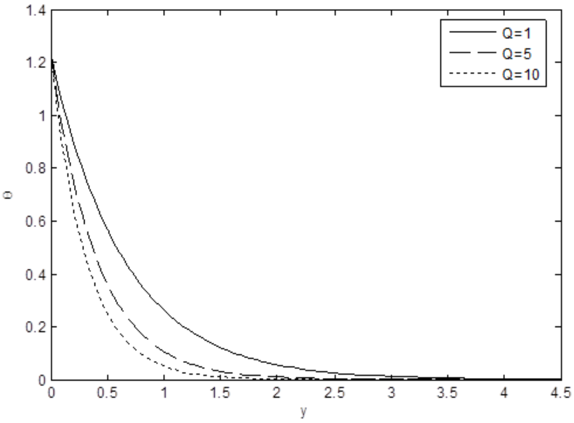

Fig 11. Temperature for different Q with Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005, h=0.3 e=0.2, Sc=1,A=1,n=0.1,m=0.4,Sr=1,R=0.5,M=3,K=2.

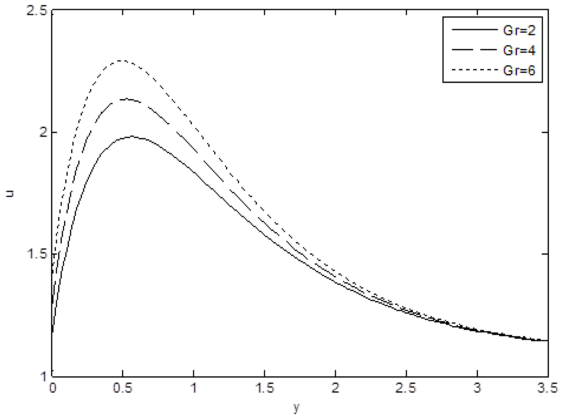

Fig 9. Velocity u versus y, under the effect Gr, for Pr=0.71,Gm=4,a=3,Q=1,Ec=0.005,h=0.3,e=0.05, Sc=0.6,A=1,n=0.5,m=0.4,Sr=1,R=2,M=3,K=1.

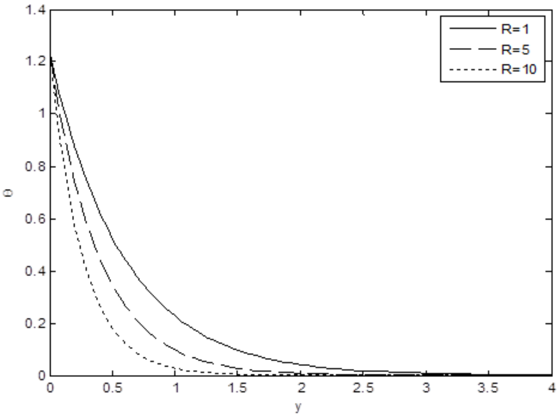

Fig 12. Temperature for different R with Gr=1,Pr=0.71,Gm=2,a=1,Q=1,Ec=0.005,h=0.3, e=0.2.Sc=0.6,A=1,K=1,n=0.1,M=0.5,m=0.4,Sr=1.

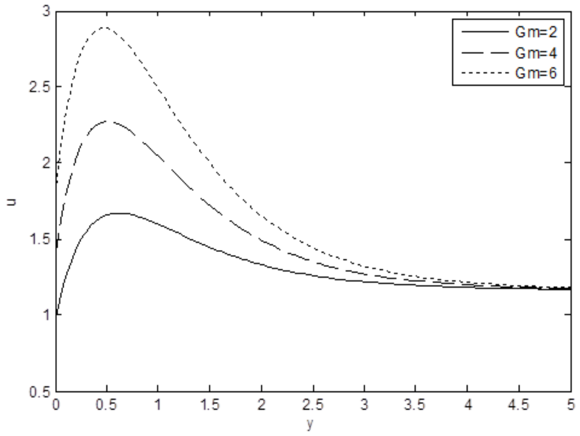

Fig 10. Velocity u versus y, under the effect Gm, for Pr=0.71,Gr=1,a=3,Q=1,Ec=0.005,h=0.3, e=0.1, Sc=0.6,A=1,n=0.5,m=0.4,Sr=1,R=2,M=3,K=1.

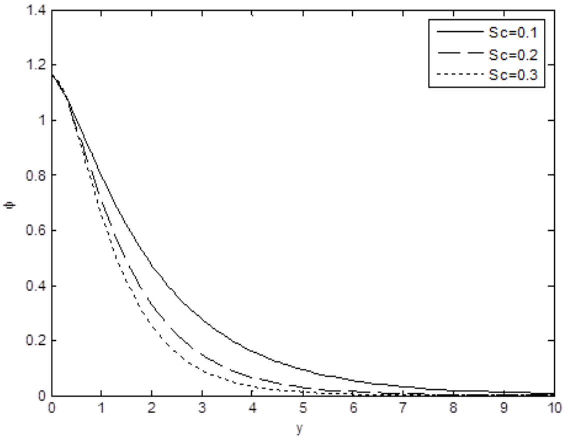

Fig 13. Concentration profile for different Sc with Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005,h=0.5,e=0.1, A=6,n=0.5,m=0.4,Sr=2,R=2,M=3,K=2,Q=2.

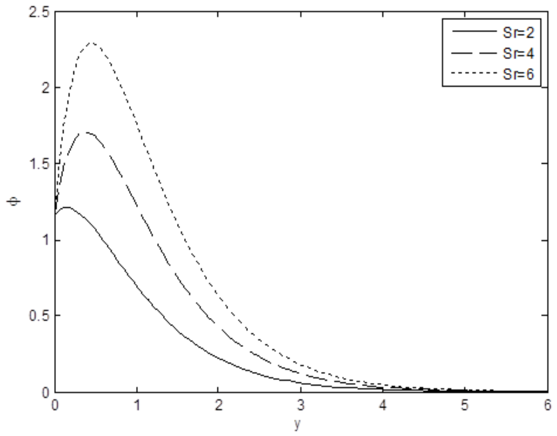

Fig 14. Concentration profile for different Sr with Gr=6,Pr=0.71,Gm=4,a=1,Ec=0.005,h=0.3,e=0.1, A=6,n=0.5,m=0.4,R=1,M=3,K=1,Q=1,Sc=0.8.

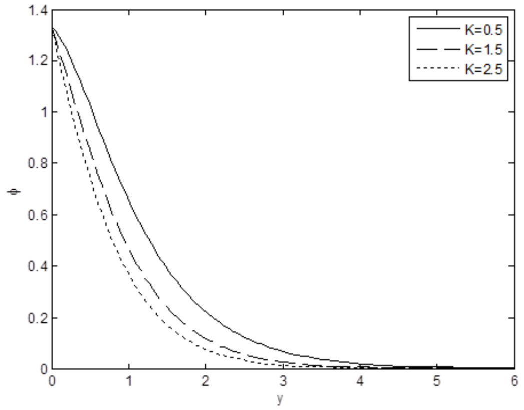

Fig 15. Concentration profile for different K with Gr=6,Pr=0.71,Gm=4,a=1,Q=1,Ec=0.005,h=0.3, e=0.2,Sc=0.6,A=4,n=0.5,m=0.4,Sr=1,R=2,M=3.

4. CONCLUSION

In this paper, unsteady mass transfer flow past a semi-infinite vertical porous plate embedded in a porous medium in a slip flow regime with Hall effect and thermal diffusion effect is studied. The flow is considered in the presence of transverse magnetic field. The main conclusions of the present analysis are as follows

1. The fluid velocity u is accelerated under the effects of Chemical reaction (K), Soret number (Sr), Rarefaction Parameter (h), Hall parameter (m), Grashof number for heat transfer (Gr), Grashof number for mass transfer (Gm).
2. For the increase of the Radiation Parameter (R) and Heat Source Parameter (Q) velocity profile u decreases.
3. The fluid velocity u decreases as the existence of the Magnetic field Parameter (M) becomes stronger.
4. An increase in Schmidt number (Sc) increases the velocity profile u and decreases the concentration profile ∅.
5. There is a fall in the temperature profile θ due to increase of Heat Source Parameter (Q) and Radiation Parameter (R).
6. The concentration profile ∅ increases with increase in Soret number (Sr).
7. With the increasing effect of Chemical reaction (K) there is a fall in the concentration profile ∅.

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