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Heat Generation and Chemical Reaction Effects On MHD Flow Over An Infinite Vertical Oscillating Porous Plate With Thermal Radiation

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ABSRACT:

The work is focused on the non linear MHD flow heat and mass transfer characteristics of an incompressible, viscous, electrically conducting and Boussinesq fluid over a vertical oscillating porous permeable plate in presence of homogeneous chemical reaction of first order, thermal radiation and heat generation effects. The problem is solved analytically using the perturbation technique for the velocity, the temperature, and the concentration field. The expression for the skin friction, Nusselt number and Sherwood number are obtained. The effects of various thermo-physical parameters on the velocity, temperature and concentration as well as the skin-friction coefficient, Nusselt number and Sherwood number has been computed numerically and discussed qualitatively.

***Keywords*: Radiation, chemical reaction, heat transfer, MHD, vertical plate, Heat generation.**

INTRODUCTION:

Magnetohydrodynamic flows have applications in meteorology, solar physics, cosmic fluid dynamics, astrophysics, geophysics and in the motion earth's core. In addition from the technological point view, MHD free convection flows have significant applications in the field of stellar and planetary magnetosphere, aeronautical plasma flows, chemical engineering and electronics. An excellent summary of applications is given by Huges and Young[1]. Raptis[2] studied mathematically the case of time varying two dimensional natural convective flow of an incompressible, electrically conducting fluid along an infinite vertical porous plate embedded in a porous medium. Helmy[3] analyzed MHD unsteady free convection flow past a vertical porous plate embedded in porous medium. Elabashbeshy[4] studied heat and mass transfer along a vertical plate in the presence of magnetic field. Chamkha[5] analyzed an unsteady, MHD convective, viscous incompressible, heat and mass transfer along a semi-infinite vertical porous plate in the presence of transverse magnetic field, thermal and concentration buoyancy effects.

The radiation effects have important applications in physics and engineering, particularly in space technology and high temperature processes. But very little is known about the effects of radiation on the boundary layer. Thermal radiation effects on the boundary layer may play important role in controlling heat transfer in polymer processing industry where the quality of the final product depends on the heat controlling factors to some extent. High temperature plasmas, cooling of nuclear reactors, liquid metal fluids, power generation systems are some important applications of radiative heat transfer. England and Emery [6] have studied the radiation effects of an optically thin gray gas bounded by a stationary plate. Raptis and Massalas [7] investigated the effects of radiation on the oscillatory flow of a gray gas, absorbing-emitting in presence induced magnetic field and analytical solutions were obtained with help of perturbation technique. They found out that the mean velocity decreases with the Hartmann number, while the mean temperature decreases as the radiation increases. The hydrodynamic free convective flow of an optically thin gray gas in the presence of radiation, when the induced magnetic field is taken into account was studied by Raptis *et al.* [8] using perturbation technique. They concluded that the velocity and induced magnetic field increase as the radiation increases. Hossain *et al.* [9] determined the effect of radiation on the natural convection flow of an optically dense incompressible fluid along a uniformly heated vertical plate with a uniform suction. Magnetohydro-dynamic mixed free–forced heat and mass convective steady incompressible laminar boundary layer flow of a gray optically thick electrically conducting viscous fluid past a semi-infinite vertical plate for high temperature and concentration differences have studied by Emad and Gamal [10]. Orhan and Kaya [11] investigated the mixed convection heat transfer about a permeable vertical plate in the presence of magneto and thermal radiation effects using the Keller box scheme, an efficient and accurate finite-difference scheme. They concluded that, an increase in the radiation parameter decreases the local skin friction parameter and increases the local heat transfer parameter. Ghosh *et al.* [12] considered an exact solution for the hydromagnetic natural convection boundary layer flow past an infinite vertical flat plate under the influence of a transverse magnetic field with magnetic induction effects and the transformed ordinary differential equations are solved exactly. As the importance of radiation in the fields of aerodynamics as well as space science technology, the present study is motivated towards this direction.

The study of heat generation or absorption in moving fluids is important in view of several physical problems, such as fluids undergoing exothermic or endothermic chemical reactions. in many chemical engineering processes, there does occur chemical reaction between a foreign mass and the fluid in which the plate is moving. These take place in numerous industrial applications viz., polymer production, manufacturing the of ceramics or glass ware and food processing. Sharma etal[13] have discussed in detail the effect of variable thermal conductivity in MHD fluid flow over a stretching sheet considering heat source and sink parameter. Chmkha and Khaled[14] investigated the problem of coupled heat and mass transfer by magneto hydrodynamic free convection from an inclined plate in the presence of internal heat generation or absorption. Bala Anki Reddy and Bhaskar Reddy[15] radiation effects on MHD combined convection and mass transfer flow past a vertical porous plate embedded in a porous medium with heat generation. Vajravelu and Hadjinicolaou[16] studied the heat transfer characteristics in the laminar boundary layer of a viscous fluid over a stretching sheet with viscous dissipation or frictional heating and internal heat generation.

In many chemical engineering processes a chemical reaction between a foreign mass and the fluid does occurs. These processes take place in numerous industrial applications, such as the polymer production, the manufacturing of ceramics or glassware, the food processing and so on Singh *et.al*[17] analyzed the effects of chemical reaction and radiation absorption on MHD free convective heat and mass transfer flow past a semi-infinite vertical moving plate withtime dependent suction. Ibrahim et.al[18] presented the effect of chemical reaction and radiation absorption on MHD flow past a continuously moving permeable surface with heat source and time dependent suction. Rajeshwari *et. al* [19] included the effects of chemical reaction on heat and mass transfer in non-linear MHD boundary layer flow with vertical porous surface in the presence of suction. An approximate numerical solution of chemical reaction, heat and mass transfer on MHD flow along a vertical stretching surface over a wedge withheat source and concentration in the presence of suction or injection was studied by Kanhaswamy *et al*[20]. Chmkha[21] studied the analytical solutions for MHD flow of a uniformly steched vertical permeable surface with effect of heat generation/absorption and chemical reaction.

The objective of this paper was to explore the effects of radiation , chemical reaction on MHD flow fluid over an infinite vertical oscillating porous plate with heat generation. The magnetic field is imposed transversely to the plate. The temperature and concentration of the plate is oscillating with time about a constant nonzero mean value. The dimensionless governing equations involved in the present analysis are solved using a closed analytical method and discussed qualitatively and graphically.

Mathematical Analysis.

Thermal radiation and mass transfer effects on unsteady MHD flow of a viscous incompressible fluid past along a vertical oscillating plate with variable temperature and also with variable mass diffusion in the presence of transverse applied magnetic field has been studied. The x' – axis is taken along the plate in the vertical upward direction and the y'-axis is taken normal to the plate. Initially it is assumed that the plate and 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 given an oscillatory motion in its own plane with velocity $U_0 \cos(w't')$. At the same time the plate temperature is raised linearly with time and also mass is diffused from the plate linearly with time. A transverse magnetic field of uniform strength B_0 is assumed to be applied normal to the plate. The induced magnetic field and viscous dissipation is assumed to be negligible as the magnetic Reynold’s number of the flow is taken to be very small. The fluid considered here is gray, absorbing/emitting radiation but a non-scattering medium. Then by usual Boussinesq’s approximation, the unsteady flow is governed by the following equations.

$$\frac{\partial u'}{\partial t'} = \frac{\partial^2 u'}{\partial y^2} + g\beta(T' - T'_\infty) + g\beta^*(C' - C'_\infty) - \frac{u'}{K'} - \frac{\sigma}{\rho} B_0^2 u' \quad (1)$$

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

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

The boundary conditions for the velocity, temperature and concentration fields are:

$$t' \le 0 : u' = 0, T' = T'_\infty, C' = C'_\infty \forall y$$

$$t' > 0 \begin{cases} u' = U_0 \cos(w't'), T' = T'_\infty + \varepsilon(T'_w + \varepsilon(T'_w + T'_\infty)e^{n't'}, C' = C'_\infty + \varepsilon(C'_w + C'_\infty)e^{n't'} \; at \; y' = 0 \\ u' \to 0, T' \to T'_\infty, C' \to C'_\infty \; as \; y' \to \infty \end{cases}$$

(4)

Where u' is the velocity in the x' –direction, K' is the permeability parameter, β is the volumetric coefficient of thermal expansion, β^* is the volumetric coefficient of expansion for concentration, ρ is the density, σ is the electrical conductivity, K- is the thermal conductivity, g is the acceleration due to gravity, T' is the temperature, T'_w is the fluid temperature at he plate, T'_∞ is the fluid temperature in the free stream, C' is the species concentration C_p is the specific heat at constant pressure, C'_∞ is the species concentration in the free stream C'_w is the species concentration at surface, D is the chemical molecular diffusivity, q_r is the radiative heat flux.

The radiant absorption for the case of an optically thin gray gas is expressed as

$$\frac{\partial^2 q_r}{\partial y'} = 4a'\sigma'(T'^4_\infty - T'^4) \quad (5)$$

Where σ' an a' are the Stefan-Boltzmann constant and the Mean absorption coefficient, respectively. we assume that the temperature differences within the flow are sufficiently small so that T'^4 can be expressed as a linear function of T' after using Taylor's series to expand T'^4 about the free stream temperature T'_∞ and neglecting higher order terms. This results in the following approximations.

$$T'^4 \cong 4T'^3_\infty T' - 3T'^4_\infty$$

(6)

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

(7)

In order to write the governing equations and the boundary conditions in dimensionless form,the following non dimensional quantities are introduced.

$$u = \frac{u'}{u_0}, y = \frac{u_0 y'}{v}, t = \frac{t' u^2{}_0}{v}, \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty}, \phi = \frac{C' - C'_\infty}{C'_w - C'_\infty}, \omega = \frac{\omega' v}{u_0^2}$$

$$K = \frac{K' u_0^2}{v^2}, \Pr = \frac{v\rho C_p}{k}, Sc = \frac{v}{D}, M = \frac{\sigma B_0^2 v}{\rho u_0^2}, Gr = \frac{v\beta g(T' - T'_\infty)}{u_0^3}, A = \frac{u_0^2}{v}$$

$$Gm = \frac{vg\beta^* C'_w - C'_\infty)}{u_0^3}, Kr = \frac{K'_r v}{u_0^2}, R = \frac{16a' v\sigma' T'^3_\infty}{k u_0^2}, Q = \frac{Q_0}{\rho C_p}\frac{v p_r}{u_0^2}$$

(8)

Using the transformations (8), the non dimensional forms of (1), (3) and (7) are

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} + Gr\theta + Gm\phi - (M + \frac{1}{K})u$$

(9)

$$\frac{\partial \theta}{\partial t} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} - \frac{R}{\Pr}\theta + Q\theta$$

(10)

$$\frac{\partial \phi}{\partial t} = \frac{1}{Sc}\frac{\partial^2 \phi}{\partial y^2} - Kr\phi$$

(11)

The corresponding boundary conditions are;

$$U = \cos(wt), \quad \theta = t, \quad \phi = t \quad at \quad y = 0$$

$$U \to 0 \quad \theta \to 0 \quad \phi \to 0 \quad y \to \infty$$

(12)

Where *Gr, Gm, M, K, Pr, R ,Q,Kr,K Sc,* are the magnetic parameter, permeability , Grashof number for heat transfer, Grashof number for mass transfer, Prandtl number, chemical reaction parameter, Schmidt number radiation parameter and heat generation respectively.

Method of solution

In order to reduce the above system of partial differential equations to a system of ordinary differential equations in dimensionless form, we assume the trail solution for the velocity, temperature and concentration as:

$$u(y,t) = u_0(y)e^{i\omega t} \quad (13)$$

$$\theta(y,t) = \theta_0(y)e^{i\omega t} \quad (14)$$

$$\phi(y,t) = \phi_0(y)e^{i\omega t} \quad (15)$$

Substituting Equations (13), (14), and (15) in equations (9), (10) and (11) we obtain:

$$u_o'' - A_3^2 = -[Gr\,\theta_0 + Gm\,\phi_0] \quad (16)$$

$$\theta_o'' - A_2^2\theta_0 = 0 \quad (17)$$

$$\phi_o'' - A_1^2\phi_0 = 0 \quad (18)$$

Here the primes denote the differentiation with respect to y.

The corresponding boundary conditions can be written as

$$u_0 = e^{i\omega t}\cos(\omega t) \quad , \quad \theta_0 = te^{i\omega t} \; , \quad \phi_0 = te^{i\omega t}$$

at y = 0

$$u_0 \to 0, \quad \theta_0 \to 0, \quad \phi_0 \to 0,$$

as $y \to \infty,$ (19)

The analytical solutions of equations (16) - (18) with satisfying the boundary conditions (19) are given by

$$u_0(y) = \{\, [\cos(\omega t) - A_4 - A_5]e^{-A_3 y} + [A_4 e^{-A_2 y} + A_5 e^{-A_1 y}] \,\}e^{-i\omega t} \quad (20)$$

$$\theta_0(y) = (te^{-A_2 y})e^{-i\omega t} \quad (21)$$

$$\phi_0(y) = (te^{-A_1 y})e^{-i\omega t} \quad (22)$$

In view of the above solutions, the velocity, temperature and concentration distributions in the boundary layer become

$$u(y) = [\cos(\omega t) - A_4 - A_5]e^{-A_3 y} + [A_4 e^{-A_2 y} + A_5 e^{-A_1 y}] \quad (23)$$

$$\theta(y) = (te^{-A_2 y}) \quad (24)$$

$$\phi(y) = (te^{-A_1 y}) \quad (25)$$

It is now important to calculate the physical quantities of primary interest, which are the local wall shear stress, the local surface heat, and mass flux. Given the velocity field in the boundary layer, we can now calculate the local wall shear stress (i.e., Skin-friction) is given by

$\tau_w^* = \mu\left(\frac{\partial u'}{\partial y'}\right)_{y'=0}$, and in dimensionless form, we obtain

$$C_f = \left(\frac{\partial u}{\partial y}\right)_{y=0} = \{[\cos(wt) - A_4 - A_5]A_3 + A_2 A_4 + A_1 A_5\,\}$$

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

$$Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = tA_2$$

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

$$Sh = -\left(\frac{\partial \phi}{\partial y}\right)_{y=0} = tA_1$$

Where

$$A_1 = \sqrt{Sc + (kr + i\omega,} \qquad A_2 = \sqrt{R - Q\Pr + i\omega\Pr},$$

$$A_3 = \sqrt{M + i\omega + \frac{1}{K}},$$

$$A_4 = \frac{-Grt}{A_2^2 - A_2 A_3^2}, \qquad A_5 = \frac{-Gmt}{A_2^2 - A_2 A_3^2}$$

Results and discussions:

To analyse the results , analytical computation has been carried out using the method described in the previous paragraph of various governing parameters namely thermal Grashof number *Gr*. Modified Grashof number *Gm*, the magnetic field parameter *M*, permeability parameter *K*, prandtl number *Pr*, radiation parameter *R*, Q heat generation parameter Schmidt number Sc and Kr chemical reaction parameter.in present study the following default parameter are adopted for computations *Gr=5, Gm=5, M=1, K=0.5, Pr=0.71, Q=0.1, Sc=0.60, Kr=0.5* $\omega = 1$. *t=pi/2.* All graphs therefore correspond to these values unless specically indicated on the appropriate graph. In order to get a physical insight in to the problem the effect of various governing parameters on the physical quantities are computed and represented in figures 1-14 and discussed in detail.

Fig.1 represents typical velocity profiles in the boundary layer for various values of the modified Grashof number, while all other parameters are kept at some fixed values. The velocity distribution attains a distinctive maximum value in the vicinity of the plate surface and then decrease properly to approach the free stream value. As expected, the fluid velocity increases and the peak value more distinctive due to increase in the concentration buoyancy effects represented by modified Grashof number. This is evident in the increase in the value of velocity as modified Grashof number increases. For the case of different values of thermal Grashof number the velocity profiles on the boundary layer are shown in Fig.2. As expected, it is observed that an increase in Grashof number leads to increase in the values of velocity due to enhancement in buoyancy force. Here the positive values of Grashof number correspond to cooling of the surface.

The effect of magnetic field on velocity profiles in the boundary layer is depicted in Fig.3 From this figure it is seen that the velocity starts from minimum value at the surface and increase till it attains the peak value and then starts decreasing until it reaches to the minimum value at the end of the boundary layer for all the values of magnetic field parameter. It is interesting to note that the effect of magnetic field is to decrease the value of the velocity profiles throughout the boundary layer. The effect of magnetic field is more prominent at the point of peak value i.e. the peak peak value drastically decreases with increases in the value of magnetic field, because the presence of magnetic field in an electrically conducting fluid introduce a force called the Lorentz force, which acts against the flow if the magnetic field is applied in the normal direction, as in the present problem. This type of resisting force slows down the fluid velocity as shown in this figure. the velocity profiles for different values of the radiation parameter, clearly as radiation parameter increases the peak values of the velocity tends to increases. Fig.4 shows the velocity profiles for different values of the permeability parameter, clearly as permeability parameter increases the peak values of the velocity tends to increase. Fig.5 shows the velocity profiles for different values of the radiation parameter, clearly as radiation parameter increases the peak values of the velocity tends to increases. Fig.6 indicates the behaviour of heat generation parameter and it shows the increase in velocity as the increase in heat generation.

For different values of the Schmidt number the velocity profiles are plotted in Fig.7. It is obvious that an increase in the Schmidt number results in decrease in the velocity within the boundary layer. Fig.8 illustrates the behaviour velocity for different values of chemical reaction parameter. It is observed that an increase in leads to a decrease in the values of velocity *Kr*. values of the velocity tends to increase. For different values of time on the velocity profiles are shown in Fig.9. It is noticed that an increase in the velocity with an increasing time *t*.

For different values of the Schmidt number the velocity profiles are plotted in Fig.5. It is obvious that an increase in the Schmidt number results in decrease in the velocity within the boundary layer. Fig.6 illustrates the behaviour velocity for different values of chemical reaction parameter. It is observed that an increase in leads to a decrease in the values of velocity. For different values of time on the velocity profiles are shown in Fig.8. It is noticed that an increase in the velocity with an increasing time . Fig.9 Velocity profiles for different values of heat generation it is observed that an increase in leads to decrease in the values of velocity. Fig.10 illustrates the temperature profiles for different values of Prandtl number. It is observed that the temperature decrease as an increasing the Prandtl number. The reason is that smaller values of Prandtl number are equivalent to increase in the thermal conductivity of the fluid and therefore heat is able to diffuse away from the heated surface more rapidly for higher values of Prandtl number. Hence in the case of smaller Prandtl number the thermal boundary layer is thicker and the rate of heat transfer is reduced. Fig.11 has been plotted to depict the variation of temperature profiles for different values of radiation parameter by fixing other physical parameters. From this Graph we observe that temperature decrease with increase in the radiation parameter *R*. Fig 12 indicates that increase in temperature shows the increase in heat generation. Fig.13 displays the effect of Schmidt number ***Sc*** on the concentration profiles respectively. As the Schmidt number increases the concentration decreases. Fig.14 displays the effect of the chemical reaction on concentration profiles. We observe that concentration profiles decreases with increasing chemical reaction parameter.

From Table.1 shows the increase in magnetic field parameter increase in the skin friction. Table.2 indicates the increase in radiation parameter shows the increase in the skin friction and Nusselt number. Table.3 shows the increase in Schmidt number shows the increase in sherwood number. .Table 4. Displays the increase in Prandtl number displays the increase in skin friction and Nusselt number. Table-5. Effects of heat generation shows the decrease in skin friction and Nusselt number.

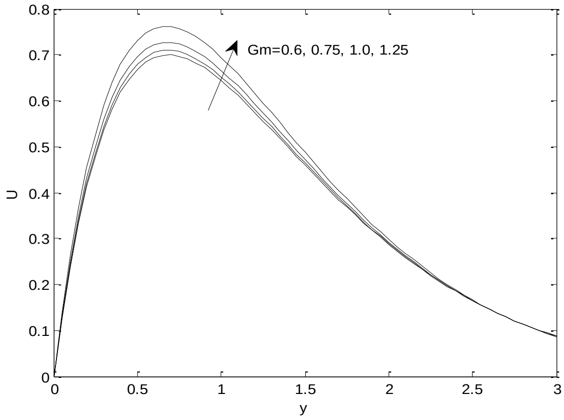

Fig-1. Velocity profiles for different values of modified Grashof number.

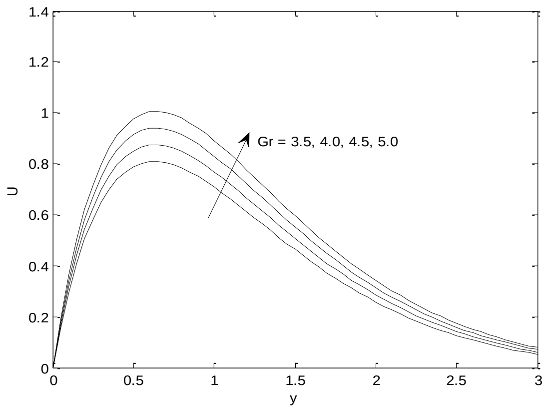

Fig-2. Velocity profiles for different values of Grashof number.

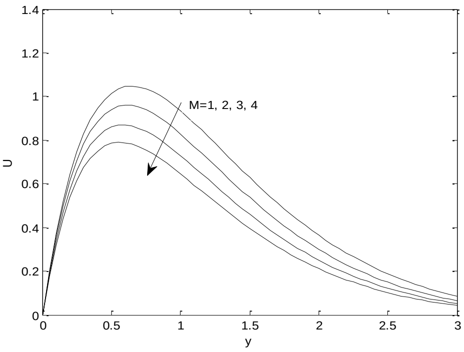

Fig -3. Velocity profiles for different values of magnetic parameter.

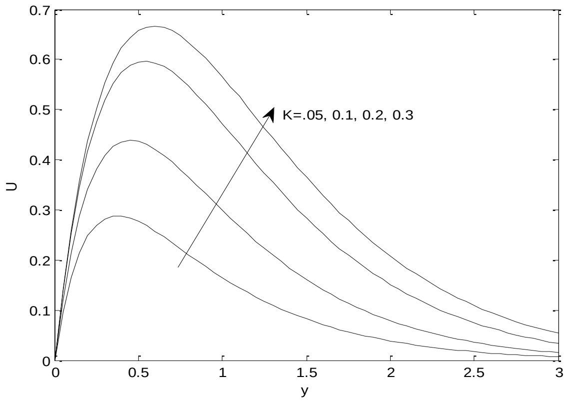

Fig-4. Velocity profiles for different values of permeability parameter.

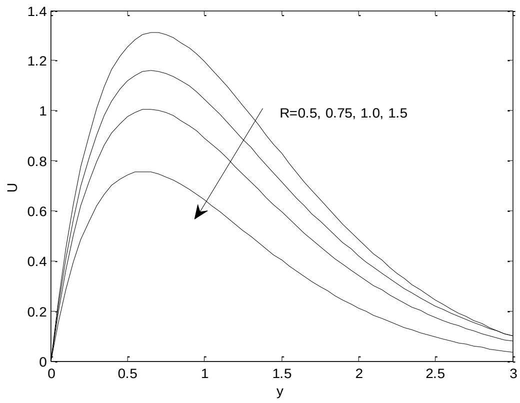

Fig-5. Velocity profiles for different values of radiation parameter.

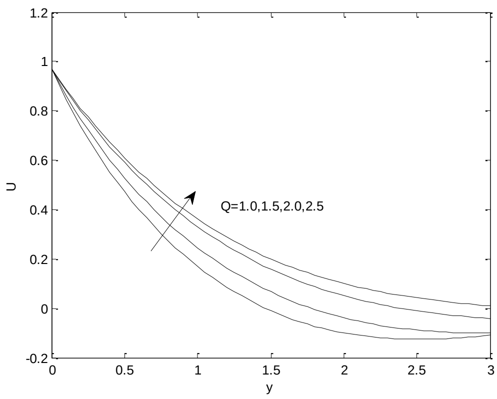

Fig-6. Velocity profiles for different values heat generation.

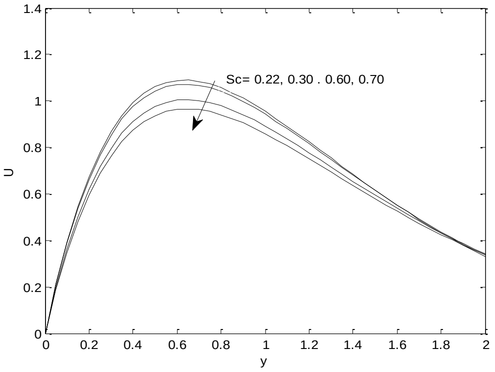

Fig-7. Velocity profiles for different values of Schmidt number.

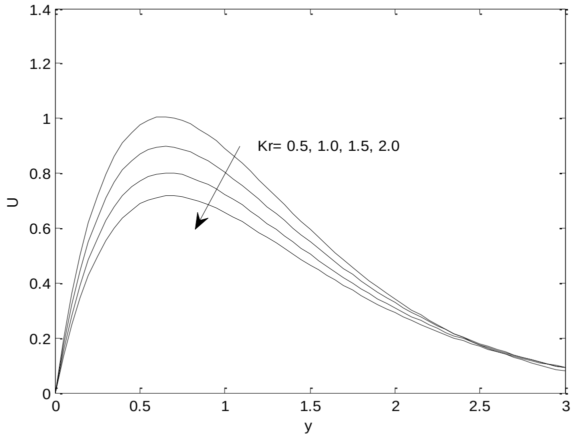

Fig-8. Velocity profiles for different values of Chemical reaction parameter.

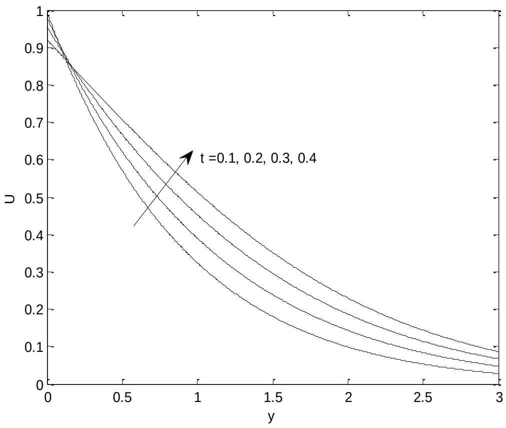

Fig-9. Velocity profiles for different values of time.

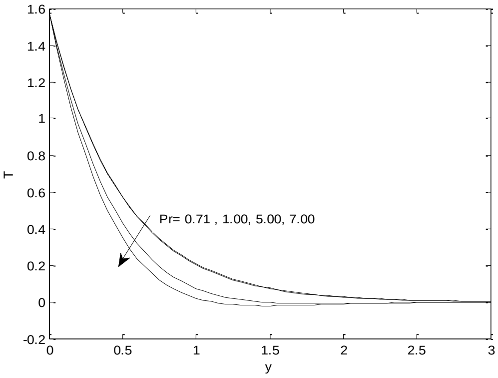

Fig-10. Temprature profiles for different values of Prandtl number.

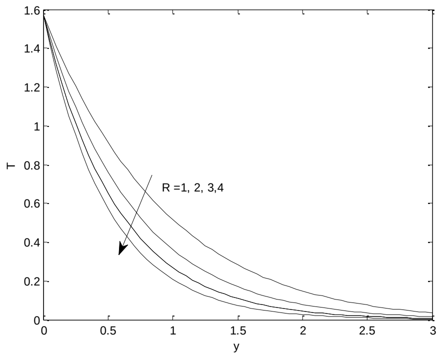

Fig-11. Temprature profiles for different values of Radiation parameter.

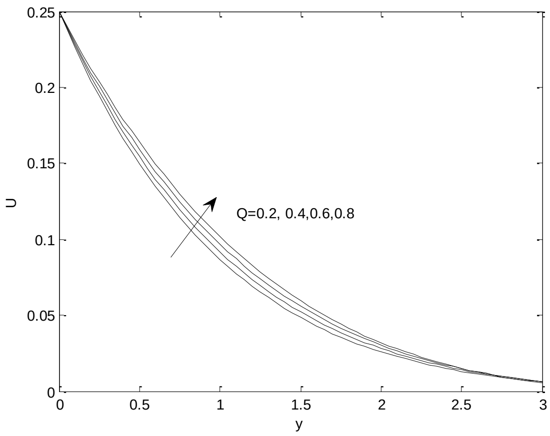

Fig-12. Temprature profiles for different values heat generation.

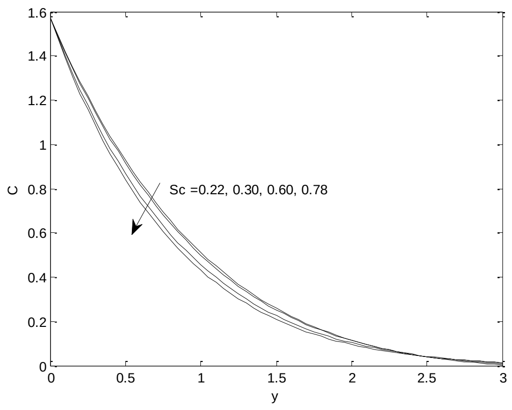

Fig-13. concentration profiles for different values Schmidt number

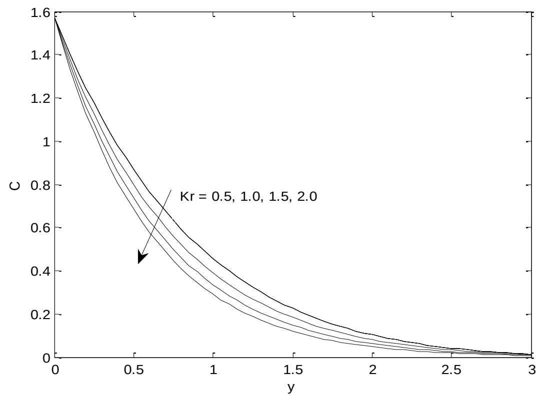

Fig-14, concentration profiles for different values of chemical reaction parameter.

Table-1. Effects of magnetic parameter on skin friction.

M	*Cf*
1.0 1.2 1.3 1.4	-0.3445 -0.3446 -0.3418 -0.3393

Table-2. Effects of radiation parameter on skin friction and nusselt number.

R	*Cf*	*Nu*
0.5 1.0 1.5 2.0	-0.7676 -07417 -0.6549 -0.5682	1.3499 1.6644 1.9621 2.2345

Table-3. Effects of Schmidt number on sherwood number.

Sc	*Sh*
2.2 0.30 0.60 0.78	1.5519 1.5599 1.7864 1.8929

Table-4. Effects of Prandtl number on skin friction and Nusselt number.

Pr	*Cf*	*Nu*
0.71 1.00 5.00 7.00	-0.9674 -0.7676 -0.1443 -0.0734	1.2461 1.3499 2.4836 2.8970

Table-5. Effects of heat generation on skin friction and Nusselt number.

Q	*Cf*	*Nu*
0.2 0.4 0.6 0.8	1.1799 1.4337 1.1095 1.0820	0.2482 0.2321 0.2156 01987

Conflict of Interests: B Lavanya, the author of this paper declares that there is no conflict of interests regarding the publication of this paper.

REFERENCES:

1. Huges WF and young FJ. The electro-magneto dynamics of fluids. Jhon wiley and sons, New York.
2. Raptis A. Flow through a porous medium in the presence of magnetic field. International journal of energy Resources, vol.10,pp.97-101.

3. Helmy KA.MHD unsteady free convection flow past a vertical porous plate.ZAMM, vol.78,pp.225-270.
4. Elabashbeshy EMA. Heat and mass transfer along a vertical plate with variable temperature and concentration in the presence of magnetic field. International journal of engineering sciences, vol.34,pp.515-522.
5. Chamka AJ . unsteady MHD convective heat and mass transfer past a semi –infinite vertical permeable moving plate with heat absorption. International journal of Engineering sciences, vol.42, pp.217-30.
6. England, W. G. and Emery, A. F. (1969): Thermal radiation effects on the laminar free convection boundary layer of an absorbing gas, J. of Heat Transfer, Vol. 91, pp. 37-44.
7. Raptis, A., and Massalas, C. V. (1998): Magnetohydrodynamic flow past a plate by the presence of radiation, Heat and Mass transfer, Vol. 34, pp. 107-109.
8. Raptis, A. A., Perdikis, C. and Leontitsis, A. (2003): Effects of radiation in an optically thin gray gas flowing past a vertical infinite plate in the presence of a magnetic field, Heat and mass Transfer, Vol. 39, pp. 771-773.
9. Hossain, M. A., Alim, M. A. and Rees, D. A. S. (1999): The effect of radiation on free convection from a porous vertical plate, Int. J. Heat and Mass Transfer, Vol. 42, No. 1, pp. 181-191.
10. Emad M. A. and Gamal El-Din A. A. (2005): Thermal radiation effects on magnetohydrodynamic flow past a semi-infinite vertical plate in the presence of mass diffusion, Can. J. Phys., Vol. 83, No. 3. Pp. 243–256.
11. Orhan A. and Ahmet K. (2008): Radiation effect on MHD mixed convection flow about a permeable vertical plate, Heat Mass Transfer, Vol. 45, pp. 239–246.
12. . S. K. Ghosh, Bég, O. A. and Zueco, J. (2009): Hydromagnetic free convection flow with induced magnetic field effects, Physics and Astronomy, Volume 45, Number 2, 175-185.
13. Sharma PR and Singh G. Effects of variable thermal conductivity and heat source/ sink on MHD flow near a stagnation point on alinearly stretching sheet. Journal of applied fluids mechanics, vol.2,pp.13-21.
14. Chamka AJ and Khaled ARA. Similarity solutions for hydromagnetic simultaneous heat and mass transfer by natural convection fron an inclined plate with internal heat generation or absorption. International journal of heat nass transfer, Vol.37pp.117-123.
15. BalaAnki Reddy and Bhashar Reddy N. radiation effects on MHD combined convection and mass transfer flow past a vertical porous plate embedded in a porous medium with heat generation. International journal of applied mathematics and Mechnics, Vol.6, no 18,pp.33-49.
16. Vajravelu K and Hadjinicolaou A . convective heat transfer in an electrically conducting fluid at a stretching surface with uniform free stream. International journal of engineering sciences , Vol.35(12-13):1237-1244.
17. Singh H, Ram p and Kumar R: A study of 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. International journal of appied Mathematical and Mechanics, Vol7(20):pp13-21.
18. Ibrahim FS, Elaiw AM and Bakr AA: effect of chemical reaction and radiation absorption on unsteady MHD free convection flow past a semi-infinite vertical permeable moving plate with heat source/suction. Communication in Non-Linear Science and Numerical Simulation, Vol 13, pp.1056-1066.
19. Rajeshwri R, jothiram B and Nelson VK: chemical reaction, heat and masss transfer on linear MHD boundary layer flow through a vertical porous surface in the presence of suction. Apllied Mathematical Sciences, Vol.3,pp2469-80.
20. Kandasamy R, Periasamy K and Sivagana Prabhu Kk: effects of chemical reaction, heat and mass transfer along a wedge with heat source and concentration in the presence of suction/injection. International journal of heat and mass transfer, Vol.48,pp.1388-94.
21. Chamka AJ: MHD flow of a numerical of uniformly steched vertical permeable surface in the presence of heat generation/absorption and a chemical reaction. International communication in Heat Mass transfer, Vol.30,pp.413-22.

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