Journal of Mathematical Control Science and Applications
Vol6 No 2 (July-December, 2020

Submitted: 19th November 2020 Revised: 10th December 2020 Accepted: 15th December 2020

THERMO DIFFUSION, HEAT AND MASS TRANSFER ANALYSIS OF MHD VISCOELASTIC FLUID FLOW TOWARDS A VERTICALLY INCLINED PLATE BY PERTURBATION TECHNIQUE

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Abstract. The problem of a hydromagnetic convective flow of an electrically incompressible viscous conducting fluid past a inclined vertical porous plate is investigated analytically, taking into consideration diffusion thermo and thermal diffusion effects. A constant suction velocity is applied to the plate. A uniformly strong magnetic field is supposed to be applied normally to the plate and directed into the fluid region. To find a solution to the problem, a perturbation method is used. The influence of several relevant flow parameters on velocity, temperature, and concentration distributions, as well as the numerical results, are studied and graphically displayed. Increasing Soret number (thermo diffusion) (*So*) hikes the concentration profile and skin friction but declines Sherwood number. Also, it has been found that, when the magnetic parameter (M) increased, the fluid velocity decreased. The current results show a good deal of agreement with previously published work. The findings of this study could be relevant in a variety of applications, including diffusion processes involving molecular diffusion of species with molar concentration.

Keywords: Chemical reaction, MHD, viscoelastic fluid, Heat and Mass transfer, free convection.

1. Introduction:

In modern engineering, many flow characteristics are not understandable with the Newtonian fluid model. Hence, the non-Newtonian fluid theory has become useful. A non-Newtonian fluid exerts nonlinear relationships between the shear stress and the rate of shear strain. Interest of the researchers in the flows of non-Newtonian fluids is on the leading edge during the last few decades because of their practical applications. Such interest in fact is accelerated because of a broad range of applications of non-Newtonian fluids in the various disciplines, for instance in biological sciences, geophysics, chemical and petroleum industries. It has an extensive industrial applications involve the flow of non-Newtonian fluids, and thus the flow behavior of such fluids finds a great relevance. Molten metal's, plastic, pulps, emulsions and raw materials in fluid state are some examples to mention. Non-Newtonian flow also finds practical applications in bio-engineering, wherein blood circulation inhuman/animal artery is explained by an appropriate Visco-elastic fluid model of small elasticity. The study of a visco-elastic pulsatile flow helps in understanding the mechanism of dialysis of blood through an artificial kidney.

Pal and Talukdar [1] used perturbation analysis to study unsteady magnetohydrodynamic convective heat and mass transfer in a boundary layer slip flow past a vertical permeable plate with thermal radiation and chemical reaction. Singh and Makinde [2] have analyzed MHD free convection flow along an inclined plate with Newtonian heating in the presence of exponentially decaying volumetric heat source. Sharma et al. [3] discussed Hall effects on thermal instability of Rivlin-Ericksen fluid. Satya Prasad Maddula [4] discussed the Finite element solutions of unsteady free convective flow towards a vertical plate in presence of magnetic field, heat and mass transfer. Gupta et al. [5] discussed on Rivlin-Erickson elastico-viscous fluid heated and solution from below in the presence of compressibility, rotation and Hall currents. Pal et al. [6] investigated magneto hydrodynamic double-diffusive convection over a stretching plate in a non-Newtonian fluid with nonlinear thermal radiation. Patil and Kulkarni [7] analyzed free convection flow in a polar fluid through porous medium by taking the effects of chemical reactions in the presence of internally generated heat. Pal et al. [8] investigated numerically MHD convection flow problem in nanofluid past a vertical nonlinear stretchable and shrinkable surface by considering heat radiation and Soret-Dufour. Pal and Mondal [9] investigated the magnetohydrodynamic convective heat-mass transfer over a vertical stretched sheet by including Soret-Dufour, and temperature-dependent viscosity effects. Anusha, T., Huang, H.N., Mahabaleshwar et al. [10] examined the two dimensional unsteady stagnation point flow of Casson hybrid nanofluid over a permeable flat surface and heat transfer analysis with radiation.

Chemical reactions generally accompany a huge amount of exothermic and endothermic reactions. These characteristics can be merely found in numerous industrial processes. There are numerous transport processes that are demonstrated by the combined action of buoyancy forces owing to both thermal and mass diffusion in the presence of chemical reaction effect. These processes take place in the solar collectors, nuclear reactor safety as well as combustion systems; chemical engineering and metallurgical fields, and so on. Prakash et al.[11] investigated the Effects of chemical reaction and radiation absorption on MHD flow of dusty viscoelastic fluid. Jithender Reddy et al. [12] have investigated significance of Casson fluid model on MHD free convection flow of an oscillating vertical permeable plate in the presence viscous dissipation. Rammohan Reddy et al.[13] have explored MHD visco-elastic and radiative free convective flow of an incompressible, chemically, electrically conducting and rotating fluid through a porous medium filled in a vertical channel within the view of thermal diffusion. Raghunath[14] et al. have discovered heat and mass transfer on MHD flow of non-Newtonian fluid over an infinite vertical porous plate. Chatterjee [15] reported about Soret-mass transfer, Dufour-heat transfer, transferring heat as well as mass in power-law governing flow. The plate is kept in a fluid at an inclined position in the medium of thermally conducting porous. Niranjan Hari et al. [16] analyzed flow with slip condition. The reactions of chemical processing, Soret-mass transfer, Dufour-heat transfer are verified using non-dimensional parameters at a stagnation point. Posteinicu[17] studied Soret temperature gradient, Dufour-concentration gradient on natural convection medium. He observed transferring heat and mass with the strength of magnetic from vertical porous surfaces. Reddy et al. [18] examined unsteady MHD free convection stream of a kuvshinski fluid past a vertical permeable plate within the sight of compound response and heat source/sink. Seetha mahalakshmi et al.(19) examined the unsteady MHD free convection flow and mass transfer near to a moving vertical plate within the sight of thermal radiation. Tripathi et al. [20] explored simultaneously the behavior MHD and chemical reaction on free convection flow towards vertical porous surface.

View of above all the present work is concerned with in this regard; the proper similarity transformations have been utilized for the reduction of the governing partial differential equations into ordinary differential equations. Graphical results for various flow parameters are presented to gain a thorough insight toward the physics of the problem.

2.MATHEMATICAL FORMULATION:

In this investigation, unsteady MHD natural convective heat and mass transfer non-newtonian viscoelastic Rivlin-Ericksen fluid flow of a viscous, incompressible, gray, absorbing-emitting but non-scattering, optically-thick and electrically conducting fluid occupying a vertical porous regime with constant velocity in presence of thermal radiation, heat absorption and chemical reaction is considered. The flow configuration of the problem is presented in Fig. 1. For this investigation, let us assume that $x'-$ axis is taken along the vertical infinite porous plate in the upward direction and the $y'-$ axis normal to the plate. Initially, for time $t' \leq 0,$ the plate and the fluid are at some temperature T'_∞ in a stationary condition with the same species concentration C'_∞ at all points.

i. A constant magnetic field B_o is maintained in the $y'-$ direction and the plate moves uniformly along the positive $x'-$ direction with velocity U_0.
ii. The magnetic Reynolds number is so small that the induced magnetic field can be neglected.

iii. At a time $t' > 0$ a magnetic field of uniform strength is applied in the direction of $y'-$ axis and the induced magnetic field is neglected.

iv. Also no applied or polarized voltages exist so the effect of polarization of fluid is negligible.

v. All the fluid properties except the density in the buoyancy force term are constants.

vi. The temperature at the surface of the plate is raised to uniform temperature T'_w and species concentration at the surface of the plate is raised to uniform species concentration C'_w and is maintained thereafter.

vii. The viscous dissipation and Ohmic dissipation of energy are negligible.

viii. The homogeneous chemical reaction of first order with rate constant $\overline{K}$ between the diffusing species is assumed.

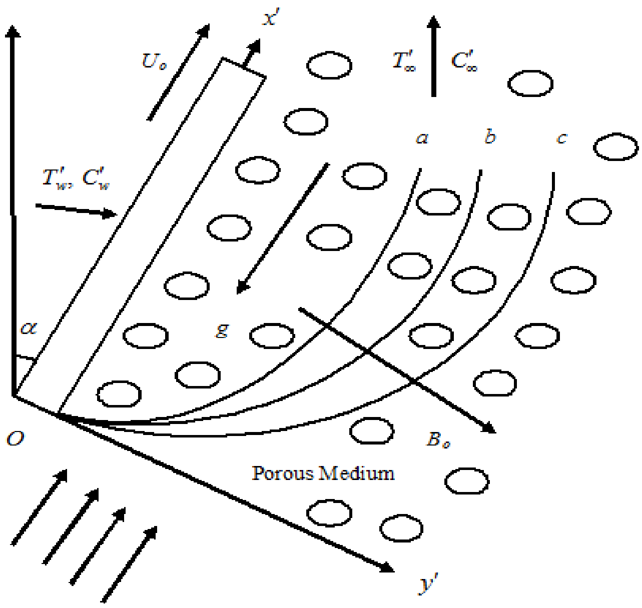

Fig 1. Physical configuration of the problem
a – Momentum boundary layer, *b* – Thermal boundary layer, *c* – Concentration boundary layer

Momentum Equation:

$$\frac{\partial u'}{\partial t'} = \nu \frac{\partial^2 u'}{\partial y'^2} - \left(\frac{\sigma B_0^2}{\rho}\right) u' - \beta_1 \left(\frac{\partial^3 u'}{\partial t' \partial y'^2}\right) + g\beta(T' - T'_\infty)(\cos\alpha) + g\beta^*(C' - C'_\infty)(\cos\alpha) \quad (2.1)$$

Energy Equation:

$$\rho C_p \frac{\partial T'}{\partial t'} = \kappa \frac{\partial^2 T'}{\partial y'^2} - \frac{\partial q_r}{\partial y'} \quad (2.2)$$

Species Diffusion Equation:

$$\frac{\partial C'}{\partial t'} = D \frac{\partial^2 C'}{\partial y'^2} - k'_r (C' - C'_\infty) + \left(\frac{D_m k_T}{T_m}\right) \frac{\partial^2 T'}{\partial y'^2} \quad (2.3)$$

Initial and boundary conditions

$$\left.\begin{array}{l} t' \le 0: \ u' = 0, \ T' = T'_\infty, \ C' = C'_\infty \ \ for \ all \ \ y' \ \& \\ t' > 0: \left\{ \begin{array}{l} u' = U_o, \ T' = T'_w, \ C' = C'_w \ \ at \ \ y' = 0 \\ u' = 0, \ T' = T'_\infty, \ C' = C'_\infty \ \ as \ \ y' \to \infty \end{array} \right. \end{array}\right\} \quad (2.4)$$

By using the Rosseland approximation, the radiative heat flux q_r is given by:

$$q_r = -\left(\frac{4\sigma_s}{3k_e}\right)\frac{\partial T'^4}{\partial y'} \tag{2.5}$$

It should be noted that by using the Rosseland approximation, the present analysis is limited to optically thick fluids. If temperature differences within the flow are sufficiently small, then equation (2.5) can be linearized by expanding T'^4 in Taylor series about T'_∞ which after neglecting higher order terms takes the form:

$$T'^4 \cong T'^4_\infty + 4(T' - T'_\infty)T'^3_\infty = 4T'T'^3_\infty - 3T'^4_\infty \tag{2.6}$$

Using Eq. (2.5) and (2.6) in the last term of Eq. (2.6), we obtain

$$\frac{\partial q_r}{\partial y'} = -\frac{16\sigma_s T'^3_\infty}{3k_e}\frac{\partial^2 T'}{\partial y'^2} \tag{2.7}$$

Introducing (2.7) in the Eq. (2.2), the energy equation becomes

$$\frac{\partial T'}{\partial t'} = \left(\frac{\kappa}{\rho C_p}\right)\frac{\partial^2 T'}{\partial y'^2} + \left(\frac{16\sigma_s T'^3_\infty}{3k_e \rho C_p}\right)\frac{\partial^2 T'}{\partial y'^2} + \left(\frac{D_m k_T}{C_S C_p}\right)\frac{\partial^2 C'}{\partial y'^2} \tag{2.8}$$

Let us introduce the following non-dimensional variables and parameters:

$$\left.\begin{array}{l} u = \dfrac{u'}{U_o},\ y = \dfrac{y'U_o}{\nu},\ t = \dfrac{t'U_o^2}{\nu},\ \theta = \dfrac{T'-T'_\infty}{T'_w - T'_\infty},\ \varphi = \dfrac{C'-C'_\infty}{C'_w - C'_\infty},\ M = \dfrac{\sigma B_o^2 \nu}{\rho U_o^2},\ \mathrm{Re} = \dfrac{U_o x'}{\nu}, \\ Gr = \dfrac{g\beta\nu\left(T'_w - T'_\infty\right)}{U_o^3},\ Gc = \dfrac{\nu g \beta^*(C'_w - C'_\infty)}{U_o^3},\ \mathrm{Pr} = \dfrac{\nu\rho C_p}{\kappa},\ Sc = \dfrac{\nu}{D},\ Q = \dfrac{Q_o \nu}{\rho C_p U_o^2}, \\ K = \dfrac{\nu^2}{K'U_o},\ Kr = \dfrac{k'_r \nu}{U_o^2},\ R = \dfrac{16\sigma_s T'^3_\infty}{3k_e\kappa},\ \lambda = \dfrac{\beta_1 U_o^2}{\nu^2},\ Du = \dfrac{D_m k_T\left(C'_w - C'_\infty\right)}{\left(T'_w - T'_\infty\right)C_S C_p \nu},\ So = \dfrac{D_m k_T\left(T'_w - T'_\infty\right)}{\left(C'_w - C'_\infty\right)T_m \nu} \end{array}\right\} \tag{2.9}$$

The above defined non-dimensionless variables in Eq. (2.9) into Eqs.(2.1), (2.3) and (2.8), and we get

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} - Mu + \lambda\left(\frac{\partial^3 u}{\partial t \partial y^2}\right) + Gr(\cos\alpha)\theta + Gc(\cos\alpha)\phi \tag{2.10}$$

$$\frac{\partial \theta}{\partial t} = \left(\frac{1}{\mathrm{Pr}}\right)\frac{\partial^2 \theta}{\partial y^2} - \left(\frac{R}{\mathrm{Pr}}\right)\theta \tag{2.11}$$

$$\frac{\partial \varphi}{\partial t} = \frac{1}{Sc}\frac{\partial^2 \varphi}{\partial y^2} - (Kr)\varphi + (So)\left(\frac{\partial^2 \theta}{\partial y^2}\right) \tag{2.12}$$

Initial conditions are

$$\left.\begin{array}{l} t' \le 0:\ u' = 0,\ T' = 1,\ C' = 1\ \ for\ \ all\ \ y'\ \& \\ t' > 0: \left\{\begin{array}{l} u' = U_o,\ T' = 1,\ C' = 1\ \ at\ \ y' = 0 \\ u' = 0,\ T' = 0,\ C' = 0\ \ as\ \ y' \to \infty \end{array}\right. \end{array}\right\} \tag{2.13}$$

3. SOLUTION OF THE PROBLEM

Equation (2.10) – (2.12) are coupled, non – linear partial differential equations and these cannot be solved in closed – form using the initial and boundary conditions (2.13). However, these equations can be reduced to a set of ordinary differential equations, which can be solved analytically. This can be done by representing the velocity, temperature and concentration of the fluid in the neighbourhood of the fluid in the neighbourhood of the plate as

$$u(y,t) = u_{00}(y) + \varepsilon e^{nt} u_{01}(y) + O(\varepsilon^2)$$
$$\theta(y,t) = \theta_{00}(y) + \varepsilon e^{nt} \theta_{01}(y) + O(\varepsilon^2) \quad (3.1)$$
$$\phi(y,t) = \phi_{00}(y) + \varepsilon e^{nt} \phi_{01}(y) + O(\varepsilon^2)$$

Substituting (3.1) in Equation (2.10) – (2.12) and equating the harmonic and non – harmonic terms, and neglecting the higher order terms of $O(\varepsilon^2)$, we obtain

Zero-order terms

$$u''_{00}(y) - Mu_{00}(y) = -Gr\theta_{00}\cos\alpha - Gc\phi_{00}\cos\alpha \quad (3.2)$$

$$\theta''_{00}(y) - R\theta_{00}(y) = 0 \quad (3.3)$$

$$\phi''_{00}(y) - ScKr\phi_{00}(y) = -ScSo\theta''_{00}(y) \quad (3.4)$$

First-order terms

$$\lambda_1 u''_{01}(y) - Fu_{01}(y) = -Gr\theta_{01}\cos\alpha - Gc\phi_{01}\cos\alpha \quad (3.5)$$

$$\theta''_{01}(y) - N\theta_{01} = 0 \quad (3.6)$$

$$\phi''_{01}(y) - A\phi_{01}(y) = -ScSo\theta''_{01}(y) \quad (3.7)$$

The corresponding boundary conditions can be written as

$$\left.\begin{array}{l} t' \le 0: \; u' = 0,\; T' = 1,\; C' = 1 \;\; for \;\; all \;\; y' \;\& \\ t' > 0: \begin{cases} u_{00} = U_o, u_{01} = 0,\; \theta_{00} = 1, \theta_{01} = 0,\; \phi_{00} = 1, \phi_{01} = 0 \;\; at \;\; y = 0 \\ u_{00} = 0, u_{01} = 0,\; \theta_{00} = 0, \theta_{01} = 0,\; \phi_{00} = 0, \phi_{01} = 0 \;\; as \;\; y \to \infty \end{cases} \end{array}\right\} \quad (3.8)$$

Solving Equations (3.2) - (3.7) under the boundary conditions (3.8) we obtain the velocity, temperature and concentration distributions in the boundary layer as

$$u(y,t) = S_3 e^{-m_1 y} + S_4 e^{-m_3 y} + D_3 e^{-m_5 y} + \varepsilon e^{nt}\left(S_5 e^{-m_2 y} + S_6 e^{-m_4 y} + D_4 e^{-m_6 y}\right)$$

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

$$\phi(y,t) = D_1 e^{-m_3 y} + S_1 e^{-m_1 y} + \varepsilon e^{nt}\left(D_2 e^{-m_4 y} + S_2 e^{-m_2 y}\right)$$

The non-dimensional skin friction, Nusselt Number and Sherwood Number are given as follows

$$\tau = \left(\frac{\partial u}{\partial y}\right)_{y=0} = -m_1 S_3 - m_3 S_4 - m_5 D_3 + \varepsilon e^{nt}\left(-m_2 S_5 - m_4 S_6 - m_6 D_4\right)$$

$$Nu = \left(\frac{\partial \theta}{\partial y}\right)_{y=0} = -m_1 - m_2$$

$$Sh = \left(\frac{\partial \phi}{\partial y}\right)_{y=0} = -m_3 D_1 - m_1 S_1 + \varepsilon e^{nt}\left(-m_4 D_4 - m_2 S_2\right)$$

4. RESULT AND DISCUSSIONS:

A analytical solution to the problem of unsteady MHD free convective chemically reacting visco-elastic fluid flow past a moving vertical plate in the presence of thermal radiation have been presented in the preceding section. In order to get the physical insight into the problem, the numerical values of the velocity field is computed for different values of the system parameters such as magnetic parameter (M), viscoelastic parameter (Γ), solutal Grashof number (Gm), thermal Grashof number (Gr), radiation parameter (R), Prandtl number (Pr), chemical reaction parameter (Kr) respectively. Throughout the computations we employ G=0.5; Kr=5; Gr=10; Gm=5; Sc=0.78; R=4; w=0.1; M=3, Pr=0.71.

Figure 2 reveals that the velocity variations with the help of the viscoelastic parameter (Γ) in case of cooling and heating of the plate at time t=0.4. It is observed that the elasticity of the fluid increases and then decreases in case of cooling ofthe plate, whereas it decreases in the case of heating of the plate, finally takes asymptotic values1.3 for both the cases. It may be concluded that the energy due elastic property of the fluid increases the velocity and then gets dissipated.

Figure 3 in case of cooling and heating of the plate. It is observed that the velocity of the fluid decreases with the increase of the magnetic parameter values for cooling of the plate at time 0.4. As expected, the velocity decreases with an increase in the magnetic parameter. It is because the application of the transverse magnetic field will result in a resistive type force (Lorentz force) similar to the drag force which tends to resist the fluid flow and thus reducing its velocity. Also, the boundary layer thickness decreases with an increase in the magnetic parameter. We also see that velocity profiles decrease with the increase of the magnetic effect indicating that the magnetic field tends to retard the motion of the fluid. The magnetic field may control the flow characteristics. The reverse phenomenon is found in the case of heating of the plate.

Figure 4 presents the plot of increase in channel porous permeability on the velocity profile. As observed, as the permeability of the medium increases there is increase in the fluid velocity since barriers placed on the flow path reduce as Da increases allowing for free flow thus increasing the velocity.

Figure (5) and (6) shows the effects of thermal Grashof number Gr and mass Grashof number Gm on the velocity profiles. From this figure it is found that the velocity increases in case of cooling of the plate. It is because that increase in the values of thermal Grashof number and mass Grashof number has the tendency to increase the thermal and mass buoyancy effect. This gives rise to an increase in the induced flow transport and a reverse effect is identified in case of heating of the plate.

The effect of the chemical reaction parameter (Kr) has shown **Figure 8** in the case cooling and heating of the plate. As expected, the presence of the chemical reaction significantly affects both profiles. It should be mentioned that the case studied relates to a destructive chemical reaction. In fact, as the chemical reaction parameter increases, a considerable reduction in the velocity occurs, and the presence of the peak indicates that the maximum velocity takes place in the fluid body close to the surface, but not at the surface itself. It is evident that an increase in this parameter significantly alters the concentration boundary-layer thickness but does not change the momentum one.

The effect of concentration, temperature profiles for different values of chemical reaction parameter is illustrated in **Figure (7) and (9)** it is found that the concentration decreases as chemical reaction parameter.

Figure 10 and (11) shows the effect of Schmidt number Sc on the velocity and concentration profiles forSc = 0:22 (hydrogen), 0:6 (water vapor), and 0:78 (ammonia). It is observed thatthe velocity and concentration decreases with increasing Schmidt number values due to the decrease inthe molecular diffusivity, which results in a decrease in the concentration and velocityboundary layer thickness.

Figure (12) shows the effect of Prandtl number (Pr) on the velocity profiles. It is observer that the velocity increases with increasing values of Prandtl number (Pr). **Figure (13)** shows the effect of Prandtl number (Pr) on the temperature profiles. It is observer that the temperature increases with increasing values of Prandtl number (Pr). **Figure (14)** shows the effect of Soret number (So) on the concentration profiles. It is observer that the concentration increases with increasing values of Soret number (So).

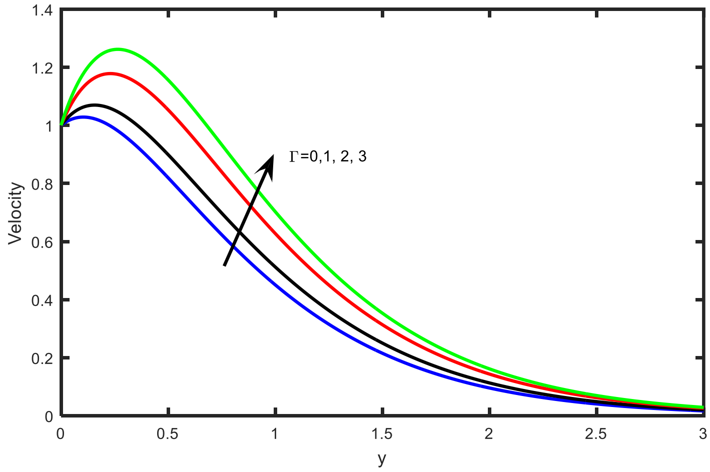

Fig.2. Velocity profiles for different values of visco-elastic parameter (Γ).

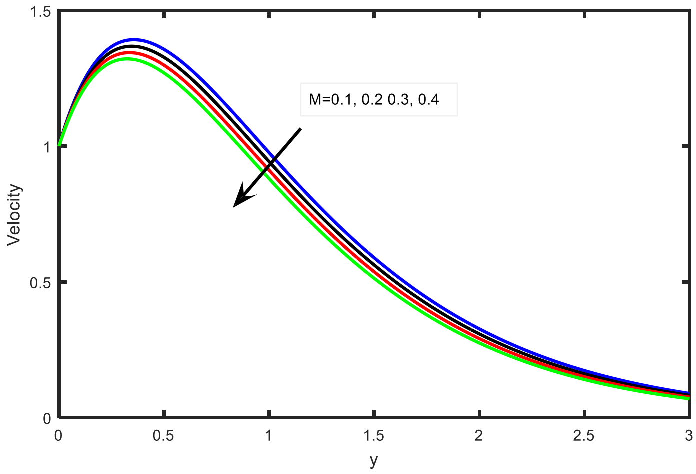

Fig.3. Velocity profiles for different values of magnetic parameter (M).

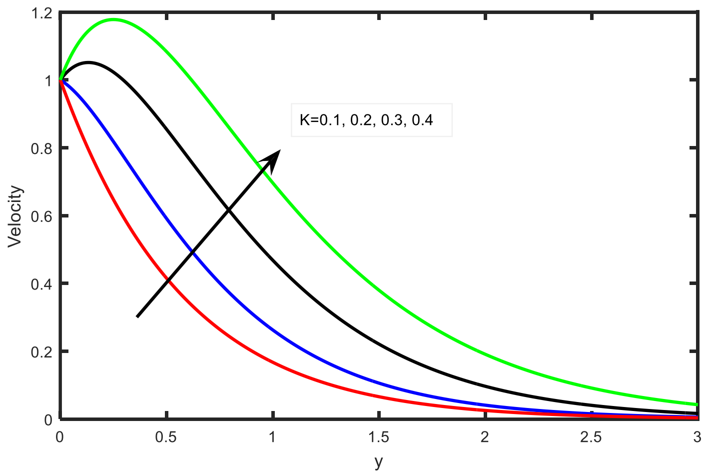

Fig.4. Velocity profiles for different values of permeability parameter (K).

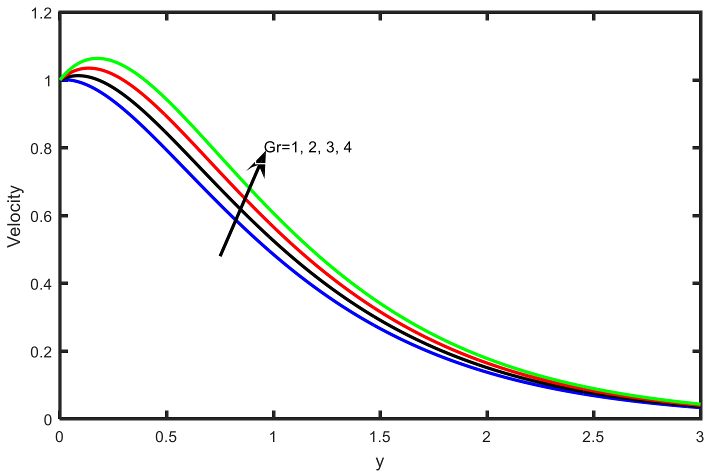

Fig.5. Velocity profiles for different values of Grashof number (Gr).

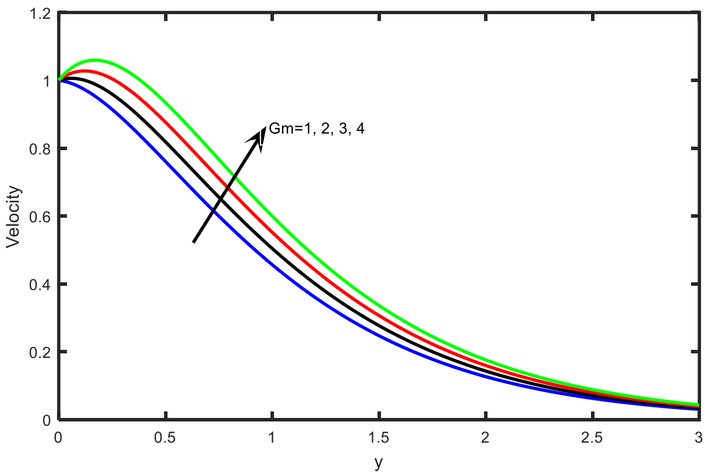

Fig.6. Velocity profiles for different values of modified Grashof number

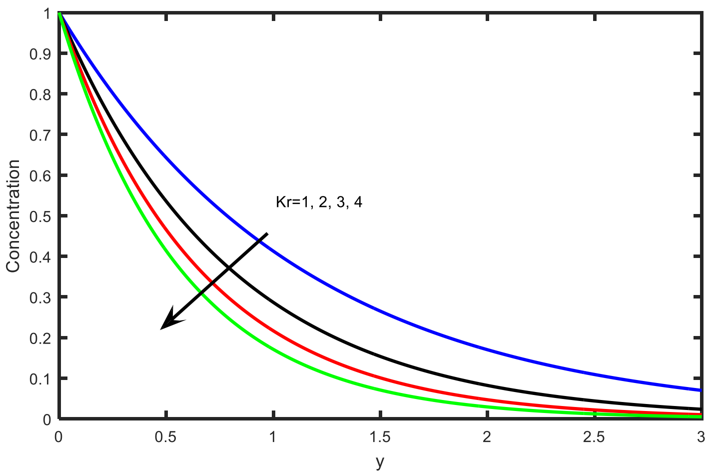

Fig.7. Concentration profiles for different values of chemical reaction parameter (Kr).

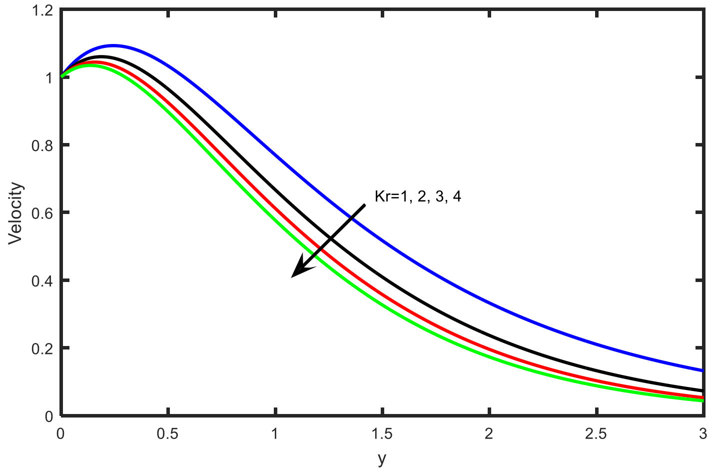

Fig.8. Velocity profiles for different values of chemical reaction parameter (Kr).

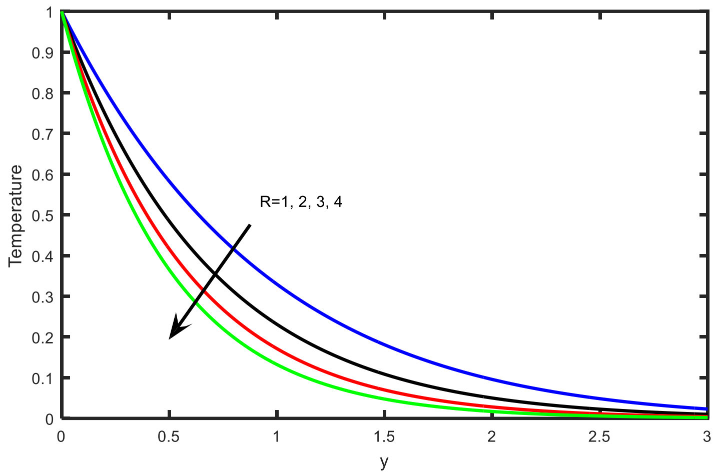

Fig.9. Temperature profiles for different values of radiation parameter (R).

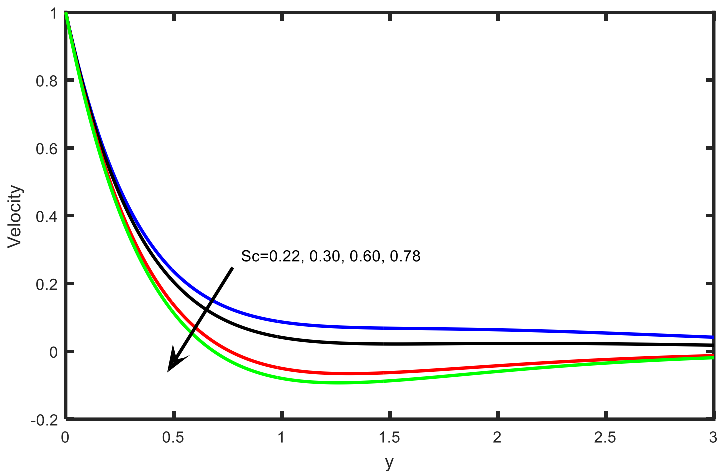

Fig.10. Velocity profiles for different values of Schmidt number (Sc).

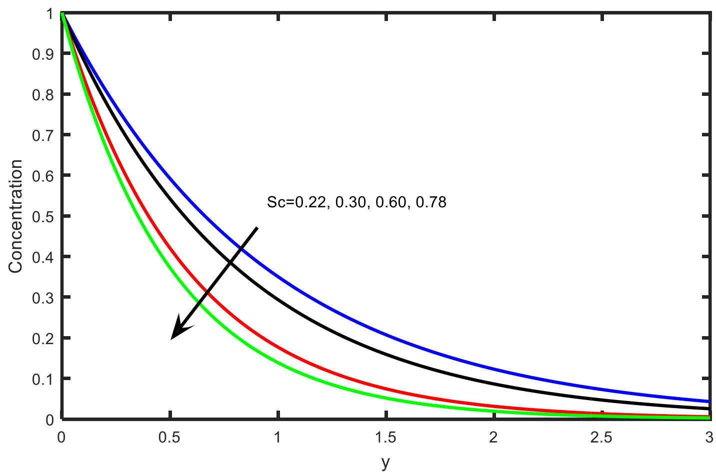

Fig.11. Concentration profiles for different values of Schmidt number (Sc).

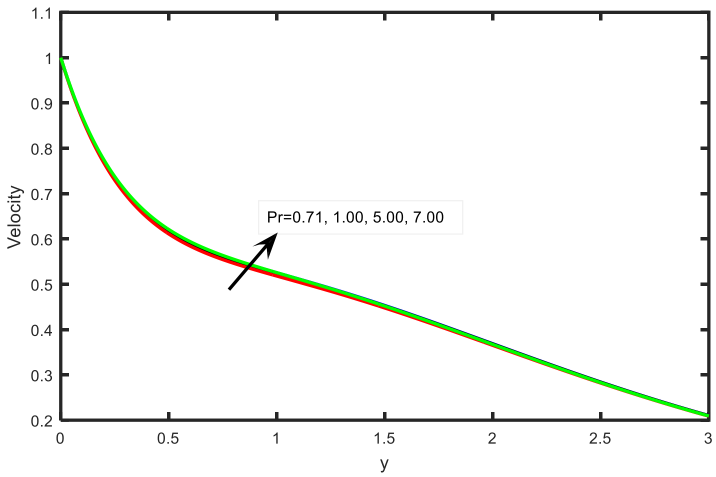

Fig.12. Velocity profiles for different values of Prandtl number (Pr).

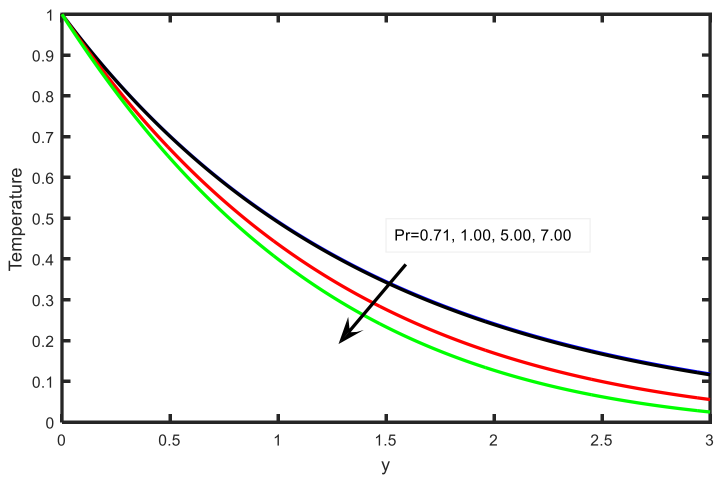

Fig.13. Temperature profiles for different values of Prandtl number (Pr).

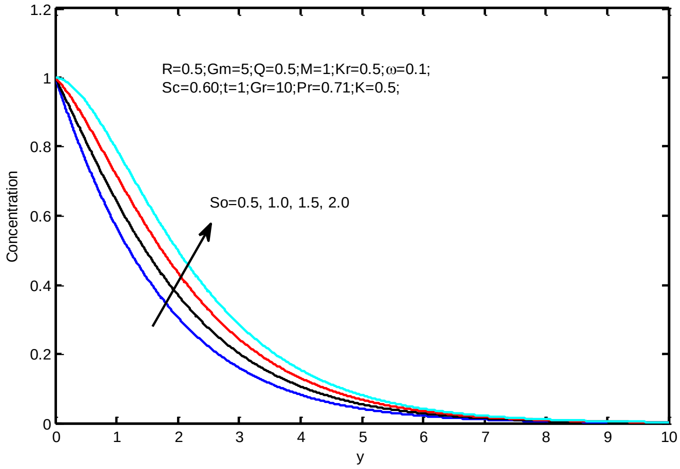

Fig.14. Concentration profiles for different values of Soret number (So).

Table for Skin friction, Nusselt number and Sherwood number values different values of Pr=0.71;G=0.5;Kr=10;Gr=10;Gm=5;Sc=0.78;R=4;i=1;w=0.1;M=3 at y=0;

Pr	Γ	Kr	Gr	Gm	Sc	R	i	w	M	Cf	Nu	Sh
0.71	0.5	5	10	5	0.78	4	1	0.1	3	-2.3729	2.0352	2.0140
0.72										-2.3726	2.0357	2.0140
0.73										-2.3722	2.0362	2.0140
0.74										-2.3719	2.0367	2.0140
0.71	0.1	5	10	5	0.78	4	1	0.1	3	-2.1840	2.0352	2.0140
	0.2									-2.2287	2.0352	2.0140
	0.3									-2.2750	2.0352	2.0140
	0.4									-2.3230	2.0352	2.0140
0.71	0.5	1	10	5	0.78	4	1	0.1	3	-2.8955	2.0352	0.9675
		2								-2.6868	2.0352	1.3100
		3								-2.5514	2.0352	1.5799
		4								-2.4516	2.0352	1.8100
0.71	0.5	5	2	5	0.78	4	1	0.1	3	0.1384	2.0352	2.8206
			4							-0.4284	2.0352	2.8206
			6							-0.9952	2.0352	2.8206
			8							-1.5619	2.0352	2.8206
0.71	0.5	5	10	2	0.78	4	1	0.1	3	-1.4204	2.0352	2.8206
				4						-1.8926	2.0352	2.8206
				6						-2.3648	2.0352	2.8206
				8						-2.8370	2.0352	2.8206
0.71	0.5	5	10	5	0.72	4	1	0.1	3	-2.1572	2.0352	2.7100
					0.74					-2.1474	2.0352	2.7474
					0.76					-2.1379	2.0352	2.7842
					0.78					-2.1287	2.0352	2.8206
0.71	0.5	5	10	5	0.78	1	1	0.1	3	-3.0559	1.0686	2.8206
						2				-2.6124	1.4636	2.8206
						3				-2.3322	1.7726	2.8206
						4				-2.1287	2.0352	2.8206
0.71	0.5	5	10	5	0.78	4	0.2	0.1	3	-2.0589	2.0035	2.7956
							0.4			-2.0655	2.0071	2.7984
							0.6			-2.0724	2.0106	2.8012
							0.8			-2.0796	2.0141	2.8040
0.71	0.5	5	10	5	0.78	4	1	0.1	3	-2.0871	2.0177	2.8068
								0.2		-2.1287	2.0352	2.8206
								0.3		-2.1783	2.0526	2.8344
								0.4		-2.2371	2.0698	2.8482
0.71	0.5	5	10	5	0.78	4	1	0.1	1	-3.6819	2.0177	2.8068
									2	-2.7427	2.0177	2.8068
									3	-2.0871	2.0177	2.8068
									4	-1.5706	2.0177	2.8068

5. CONCLUSIONS:

We have examined the unsteady free convective chemically reacting, MHD visco-elastic fluid flow past an infinite vertically inclined plate with uniform temperature and also with uniform mass diffusion in the presence of thermal radiation. The dimensionless governing partial differential equations are solved by usual perturbation method; we can conclude the following results:

- The fluid velocity increases with increasing parameters Γ ,K, Gr, Gm and Pr for cooling of the plate whereas the reverse effectis found in the case of heating of the plate.

- The fluid velocity decreases with increasing values of the parameters M, *Kr*and Sc for cooling of the plate, for heating ofthe plate.
- The fluid temperature decreases with increasing values of *R*(radiation parameter) or *Pr* (Prandtl number) while it increaseswith *t* (time).
- The fluid concentration decreases with increase in *kr*(chemical reaction parameter) and *Sc* (Schmidt number) whileit increases with *t* (time).
- The fluid concentration increases with increase in *So*(Soret number)

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Appendix:

$$N = n\,\mathrm{Pr} + R,\quad \lambda_1 = n\lambda + 1,\; F = M + n,\; A = Sc(n + K_r),$$

$$m_1 = -\sqrt{R},\; m_2 = -\sqrt{N},\; m_3 = -\sqrt{ScSr},\; m_4 = -\sqrt{A},$$

$$m_5 = -\sqrt{M},\quad m_6 = -\sqrt{\frac{F}{N}},\; D_1 = 1 - S_1,$$

$$D_2 = 1 - S_2, D_3 = U_0 - S_3 - S_4,\; D_4 = -S_5 - S_6,$$

$$S_1 = \frac{-ScSrm_1^2}{m_1^2 - ScKr},\; S_2 = \frac{-ScSrm_2^2}{m_2^2 - ScKr}, S_3 = \frac{-(Gr + GcS_1)\cos\alpha}{m_1^2 - ScKr},$$

$$S_4 = \frac{-GcD_1\cos\alpha}{m_3^2 - ScKr}, S_5 = \frac{-(Gr + GcS_2)\cos\alpha}{\lambda m_2^2 - ScKr}, S_6 = \frac{-GcD_2\cos\alpha}{\lambda m_4^2 - ScKr}.$$

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