Journal of Mathematical Control Science and Applications
Vol7 No. 2 (July-December, 2021)

Submitted: 07rd August 2021 *Revised: 19th September 2021* *Accepted: 15th October 2021*

A PERTURBATION ANALYSIS FOREFFECTS ON CHEMICAL REACTIONAND THERMAL RADIATION ON TEMPERATURE AND CONCENTRATION ON MHD FREE CONVECTION FLOW PAST A VERTICAL POROUS PLATE IN THE PRESENCE OF AND HEAT SOURCE PARAMETER

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Abstract: In the present article studied the effects ofchemical reaction andthermal radiation on temperature and concentration on MHD free convection flow past a vertical porous plate in the presence of heat source parameter. The dimensionlessgoverning equations velocity, concentration and temperature are solved analytically by using perturbation method. The flow phenomenon has been considered with the help of flow parameters like Grashof number, Modified Grashof number, Eckert number, radiation parameter, heat source parameter, Schmidth number, Prandtl number etc. The effects of these flow parameters on Velocity, temperature and concentration fields are studied and discussed graphically with the help of MATLAB.The differences in skin friction, Nusselt number and Sherwood number are presented in tables.

Keywords: Chemical reaction, Mass diffusion, Eckert number, Radiation, MHD, Time dependent variable.

1. Introduction

Free convection stream connecting to heat transfer happens frequently in an environment where transformations between land and air temperature can give escalation to complicated flow patterns and free convection arises in fluids when temperature changes results in density variation leading to buoyancy forces acting on the fluid elements. The study of heat and mass transfer to chemical reacting MHD free convection flow with radiation effects on a vertical plate has received a growing interest during the last decades. Heat transfer through thermal radiation is great reputation when we are concerned with space applications, sophisticated temperatures and also power engineering. Accurate knowledge of the overall convection heat transfer has vital importance in several fields such as thermal insulation, drying of porous solid materials, heat exchanges, stream pipes, water heaters, refrigerators, electrical conductors and industrial, geophysical and astrophysical applications, such as polymer production, manufacturing of ceramic, packed-bed catalytic reactors, food processing, cooling of nuclear reactors, enhanced oil recovery, underground energy transport, magnetized plasma flow, high speed plasma wind, cosmic jets and stellar system.

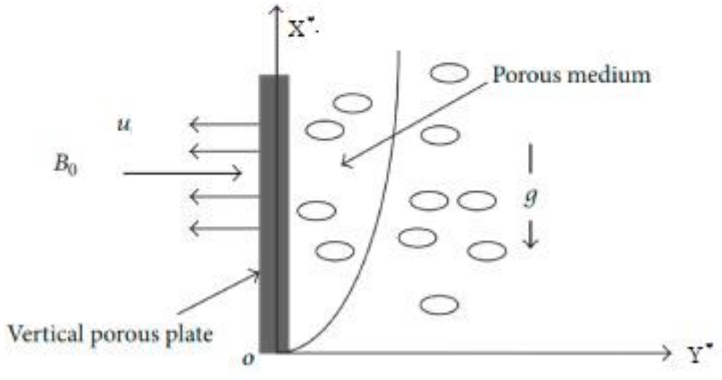
An instable magnetohydrodynamics convective heat transmission past a semi-infinite perpendicular permeable moving dish with inconstant force discussed by Kim [1]. Chen [2] talk about mass &heat allocation in magnetohydrodynamics flow through usual convection as of a porous disposed surface thru variable fence concentration and temperature. Hayat et al [3] explored radioactivity possessions on magnetohydrodynamics stream in a spongy space. Hossain et al. [4] analysed the consequence of radioactivity on unrestricted convection as of an impermeable perpendicular plate. Israel-Cookey et al. [5] examinedthe result of viscid degeneracy and radioactivity of heat and mass transmission in an erect immeasurable plate with time-dependent pressure in a spongy channel K. Balamurugan et al. [6], investigatedMHD free convection flow past a vertical porous plate in a slip flow regime with radiation chemical reaction and temperature gradient dependent heat source in presence of Dufour effect. Singh et al [7] studied magnetohydrodynamics allowed convection and mass transfer flow with thermal diffusion and heat source. Kandasamy et al. [8] analysed the possessions of chemical reaction, mass and heat transmission along a piece through concentration and heatsource in the company of suction. Seth et al. [9]

deliberated the effects of Hall current and spin on hydromagnetic usual convection stream thru mass and heat transmission of a heat engrossing fluid past an unwarily moving perpendicular plate with ramped temperature. Anjalidevi and Kandasamy [10] explored the results of chemical response, mass and heat transference on smooth flow of a liquid along a semi-infinite parallel plate.V Nagaraju et al [11] discussed the radiation effects on MHD convective heat and mass transfer flow past a semi-infinite vertical moving porous plate in the presence of chemical reaction. Omeshwar Reddy et al. [12] examined the finite difference solutions of MHD natural convective Rivlin-ericksen fluid flow past a vertically inclined porous plate in presence of thermal diffusion, diffusion thermo, heat and mass transfer effects. V SrihariBabu et al. [13] investigated the MHD Viscoelastic Fluid flow Past an Infinite Vertical Plate in the Presence of Radiation and Chemical Reaction. Makinde [14] scrutinized unconfined convection stream with thermal radioactivity and mass conversion past a moving erect permeable platter. D ChennaKesavaiah and B Venkateswarlu [15] were studied the chemical reaction and radiation absorption effects on convective flows past a porous vertical wavy channel with travelling thermal wavesB Mallikarjuna Reddy et al. [16] analysed the radiation and diffusion thermo effects of viscoelastic fluid past a porous surface in the presence of magnetic field and chemical reaction with heat source. Effect of chemical impact on heat and mass transmission of a marginal layer flow thru heat swaping was explored by Chamkha [17]. Postelnicu A [18] has studied the influence of chemical reaction on heat andmass transfer by natural convection from vertical surfaces in porous media considering Soret and Dufour effects. Malga et al [19] look over the effect of radiating liquefied on unrestricted convective heat transmission through spongy channel in existence of induced magnetic arena. Shankar Goud et al [20] analysed the effect of Soret numeral on magnetohydrodynamic allowed convection movement of heat and mass transfer of an electrically leading non-Newtonian liquid through an erect working on a porous plate. S venkateshwarlu et al.[21] analysed the result of dufour numeral together with vicious circle on magnetohydrodynamic movement of Jeffrey liquid over a perpendicular penetrable plate. Lakshmi et al [22] analysed the radiation and chemical reaction effects on unsteady MHD free convention mass transfer fluid flow in a porous plate. The impact of magnetic strength on MHD drift in nonappearance of heat movement in changed preparations within reality of Darcian porous has studied by S.Venkataramana [23]. Appidi L et al. [24] has been discussed the effects of Thermal Radiation on Temperature and Concentration on MHD Free Convection Flow Past a Vertical Porous Plate in the Presence of Chemical Reaction and Heat Source Parameter. K.Hemalatha et al. [25] investigated the radiation and Chemical Reaction effects on MHD mixed convective flow of a vertical surface with Ohmic heating and viscous.Appidi L et al. [26] discussed about the finite element analysis of viscous dissipation effects on unsteady free convention and mass transfer flow of fluid in a porous media with chemical reaction and heat source parameter.Lakshmi et al [27] analysed one-dimensional instable unrestricted convention and mass transfer flow of micro-polar fluid surrounded in a porous panel with vicious circle. Omeshwar Reddy V and Thiagarajan S [28] were discussed Rivlin-Ericksen fluid effect on mixed convective fluid flow past a wavy inclined porous plate in presence of soret, dufour, heat source and thermal radiation: a finite difference technique.

View of above all studies in this article we expanded study is in addition with Eckert number extension of Effects of MHD Free Convection Flow Past a

Vertical Porous Plate in the Presence of Thermal Radiation and Chemical Reaction with the help of perturbation method and MATLAB.

2. FORMULATION OF THE PROBLEM



The instable stream of an electrically accompanying incompressible, viscid, radiative along with chemically reactive liquid past an immeasurable erect plate with inconstant temperature and concentration over an absorbent medium in the existence of temperature basis has been measured. The stream is supposed to be in X*-path which is engaged along the vertical plate in the upward direction. The Y*-direction is taken to be normal to the plate. Originally, it is supposed that together liquefied and plates are on respite and at similar temperature T_∞^* and concentrationC_∞^*. At t*>0 the temperature and concentration of the plate Y*=0 is raised to $T_\infty^* + (T_w^* - T_\infty^*)e^{a^*t^*}$ and $C_\infty^* + (C_w^* - C_\infty^*)e^{a^*t^*}$ with time t and there after remains constant that of $y^* \to \infty$ is lowered to $T_\infty^*$and C_∞^* . A diagonal magnetic field of unvarying asset is supposed to be functionalized usual to plate. The persuaded viscous dissipation and magnetic field is supposed to be insignificant as the magnetic Reynold numeral of the stream is considered to be very less. The divergence effects are supposed to be small and hence the electric arena is too small. The absorption of the diffusing classes in the double mix is supposed to be neglible in contrast with another chemical reactions, which are contemporary and henceforth Dafour and Soret results are insignificant. Now hall effect of magnetohydrodynamic and magnetic degeneracy are deserted.

As per the previous supposition by the normal Boussineq's calculation, the governing equivalences and boundary layer circumstances are mentioned as below

Momentum:

$$\frac{\partial u^*}{\partial t^*} = \nu \frac{\partial^2 u^*}{\partial y^{*2}} + {}^{g}\beta(T^* - T_\infty^*) + {}^{g}\beta^*(C^* - C_\infty^*) - \frac{\sigma B_0^2}{\rho} u^* - \frac{\nu}{K_p^*} u^* \quad (2.1)$$

Energy:

$$\rho C_p \frac{\partial T^*}{\partial t^*} = k \frac{\partial^2 T^*}{\partial y^{*2}} + Q_0(T^* - T_\infty^*) - \frac{\partial q_r{}^*}{\partial y^*} \qquad (2.2)$$

Concentration:

$$\frac{\partial C^*}{\partial t^*} = D \frac{\partial^2 C^*}{\partial y^{*2}} - K_r^*(C^* - C_\infty^*) \quad (2.3)$$

Initial and Boundary conditions are:

$$u^* = 0, T^* = T_\infty^*, C^* = C_\infty^* \; for all \; y^*, t^* \leq 0$$

$$t^* > 0 : \; u^* = u_0, T^* = T_\infty^* + (T_w^* - T_\infty^*)e^{a^*t^*}, C^* = C_\infty^* + (C_w^* - C_\infty^*)e^{a^*t^*} at \; y^* = 0$$

$$u^* \to 0, T^* \to T_\infty, C^* \to C_\infty \; as \; y^* \to \infty \qquad (2.4)$$

The local radiant interest for the instance of an optically tinny Grayvapor is stated (Raju et al.[16] and Raju KVS[18]) as

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

here a' is the mean absorption co-efficient and σ^* is the Stefan-Boltzmann constant. Now we done that the transformations inside the flow are adequately small so that T^{*4} can be stated that as a linear function of T^* later using Taylor's series to enlarge T^{*4} about the unrestricted flow temperatureT_∞^{*4} and ignoring the higher order terms. This result is in the following approximation: $T^{*4} \cong 4T_\infty^{*3}$- $3T_\infty^{*4}$.

Now equation (2) takes the following form

$\rho C_p \frac{\partial T^*}{\partial t^*} = k\frac{\partial^2 T^*}{\partial y^{*2}} + q_0(T^* - T_\infty^*) - 16a'\sigma^* T_\infty^{*3}(T^* - T_\infty^*)$(2.5)

Introducing the following non-dimensional quantities:

$u=\frac{u^*}{u_0}$, $t=\frac{t^* u_0^2}{\nu}$, $y=\frac{y^* u_0}{\nu}$, $\theta=\frac{T^*-T_\infty^*}{T_w^*-T_\infty^*}$, $C=\frac{C^*-C_\infty^*}{C_w^*-C_\infty^*}$, $Gr=\frac{\nu^g\beta(T_w^*-T_\infty^*)}{u_0^3}$, $Gc=\frac{\nu^g\beta^*(C_w^*-C_\infty^*)}{u_0^3}$,$M=\frac{\sigma\nu B_0^2}{\rho u_0^2}$,$K=\frac{K_p^* u_0^2}{\nu^2}$,$P_r = \frac{\mu C_p}{k}$, $R= (\frac{16a'\sigma^* T_\infty^{*3}\nu^2}{k u_0^2})$, $Sc = \frac{\nu}{D}$, $K_r = \frac{K_r^*\nu}{u_0^2}$, $a=\frac{a^*\nu}{u_0^2}$, $Q = \frac{Q_0\nu^2}{k u_0^2}$

(2.6)

After introducing the non-dimensional quantities in to the equations (2.1),(2.2)and(2.5), these equations reduce to the following forms

$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} + G_r\theta + G_m C - Mu - \frac{1}{K}u$ (2.7)

$P_r\frac{\partial\theta}{\partial t} = \frac{\partial^2\theta}{\partial y^2} + Q\theta - R\theta + Ec(\frac{\partial u}{\partial y})^2$(2.8)

$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} - K_r C$ (2.9)

The corresponding boundary &initial conditions are

$u = 0, \theta = 0, C = 0 \quad forall\, y, t \le 0$

$t > 0 : u = 1, \theta = e^{at}, C = e^{at} \quad at\, y = 0$

$u \to 0, \theta \to 0, C \to 0 \quad as\, y \to \infty$ (2.10)

3. METHOD OF SOLUTION

Equations (7) – (9) are coupled, non – linear partial differential equations and these cannot be solved in closed – form using the initial and boundary conditions (10). 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

$$u(y,t) = u_0(y) + \varepsilon e^{at}u_1(y) + O(\varepsilon^2)$$
$$\theta(y,t) = \theta_0(y) + \varepsilon e^{at}\theta_1(y) + O(\varepsilon^2)$$
$$C(y,t) = C_0(y) + \varepsilon e^{at}C_1(y) + O(\varepsilon^2) \qquad (3.1)$$

Substituting (2.11) in Equation (2.7) – (2.9) and equating the harmonic and non – harmonic terms, and neglecting the higher order terms of $O(\varepsilon^2)$, we obtain

Zero-order terms

$$u_0'' - Nu_0 = -Gr\,\theta_0 - Gc\,C_0 \qquad (3.2)$$

$$\theta_0'' - F\theta_0 = 0 \qquad (3.3)$$

$$C_0'' - Kr\,Sc\,C_0 = 0 \qquad (3.4)$$

First-order terms

$$u_1'' - (M + a)u_1 = -Gr\,\theta_1 - Gc\,C_1 \qquad (3.5)$$

$$\theta_1'' - \Pr\left(F+n\right)\theta_1 = (u_0')^2 \tag{3.6}$$

$$C_1'' - \left(Kr+a\right)Sc\,C_1 = 0 \tag{3.7}$$

The corresponding boundary conditions can be written as

$$\begin{aligned} & u=0, \quad \theta=0, \quad C=0, \quad \text{forall} \quad y\le 0 \,\&\, t\le 0 \\ t>0: \quad & u_0=0,\ \theta_0=0,\ C_0=0,\ u_1=1,\ \theta_1=1,\ C_1=1 \quad \text{at} \quad y=0 \\ & u_0\to 0, \theta_0\to 0, C_0\to 0, u_1\to 0, \theta_1\to 0, C_1\to 0 \quad \text{as} \quad y\to\infty. \end{aligned} \tag{3.8}$$

Solving Equations (12) - (17) under the boundary conditions (18) we obtain the velocity, temperature and concentration distributions in the boundary layer as

$$u_0 = S_3e^{-m_3y} - S_2e^{-m_2y} - S_1e^{-m_1y};$$

$$u_1 = S_{18}e^{-m_5y} + S_{11}e^{-m_4y} + S_{12}e^{-2m_3y} + S_{13}e^{-2m_2y}$$
$$+S_{14}e^{-2m_1y} - S_{15}e^{-(m_3+m_1)y} - S_{16}e^{-(m_3+m_2)y} - S_{17}e^{-(m_2+m_1)y}$$

$$\theta_0 = e^{-m_2y};$$

$$\theta_1 = S_{10}e^{-m_4y} + S_4e^{-2m_3y} + S_5e^{-2m_2y} + S_6e^{-2m_1y}$$
$$-S_7e^{-(m_2+m_3)y} - S_8e^{-(m_1+m_3)y} - S_9e^{-(m_2+m_1)y}$$

$$C_0 = e^{-m_1y}; C_1 = 0$$

In view of the above

$$u(y,t) = S_3e^{-m_3y} - S_2e^{-m_2y} - S_1e^{-m_1y}$$
$$+\varepsilon e^{at}\begin{bmatrix} S_{18}e^{-m_5y} + S_{11}e^{-m_4y} + S_{12}e^{-2m_3y} + S_{13}e^{-2m_2y} + S_{14}e^{-2m_1y} \\ -S_{15}e^{-(m_3+m_1)y} - S_{16}e^{-(m_3+m_2)y} - S_{17}e^{-(m_2+m_1)y} \end{bmatrix}$$

$$\theta(y,t) = e^{-m_2y} + \varepsilon e^{at}\begin{bmatrix} S_{10}e^{-m_4y} + S_4e^{-2m_3y} + S_5e^{-2m_2y} + S_6e^{-2m_1y} \\ -S_7e^{-(m_3+m_1)y} - S_8e^{-(m_3+m_2)y} - S_9e^{-(m_2+m_1)y} \end{bmatrix}$$

$$C(y,t) = e^{-m_1y}$$

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

$\tau = \left(\frac{\partial u}{\partial y}\right) at y = 0$; $N_u = -\left(\frac{\partial \theta}{\partial y}\right) at y = 0$; $Sh = -\left(\frac{\partial C}{\partial y}\right) at y = 0$

4. Results & Discussion

A numerical investigative education has been supported out on the Magneto hydro dynamics flow of a viscous fluid. In the present study effects of physical parameters such as permeability parameter, Grashof number, Eckert number, modified Grashof number, magnetic parameter, radiation parameter, heat source parameter, Prandtl number, Schmidth number and chemical reaction parameter on Velocity, Temperature and species concentration are discussed with the help of graphs where labelled as **1-5; 6-9** and **10-12** respectively.

Fig 1 shows that velocity rises with rises of permeability parameter. It is because of that rises the values of K reduce the strain energy which supports the fluid significantly to transfer fast. **Fig 2** shows the effect of thermal Grashof number where as Gr increases Velocity also increases. It is because of that buoyancy which is acting on the fluid particles due to the gravitational force that enhancing the fluid velocity.

Fig 3 As per the discussion was made in fig2 modified Grashof number which also increases the velocity.

Fig 4 shows the effect of Magnetic parameter where M increases that the velocity decreases. **Fig 5** shows the effect of Eckert number increases Velocity also increases.

Fig 6 shows the effect of Radiation parameter on temperature, it is noticed that temperature decreases radiation parameter increases.

Fig 7 shows the effect of heat source parameter on temperature. It is observed that temperature increased by an increase in heat source by the fluid. This is due to the effect of heat source sources an increase in the kinetic energy in addition to thermal energy of the fluid. The thermal boundary layer and momentum get stripper in case of heat source fluids. **Fig 8** shows the effect of Prandtl number on temperature. It observed that increase Pr substantially decreases the temperature in the viscous fluid that solutal boundary layer thickness of the fluid enhances with the increase of Pr.

Fig 9 shows the effect of Eckert number on temperature.it is noticed that increasing of Eckert number temperature also increases.

Fig 10 shows that the effects of Schmidth number on concentration. It is observed that concentration decreases with an increase in Schmidth number. Because, Schmidth number is a dimensionless number it is denoted and defined as the ratio of momentum diffusivity and mass diffusivity and is used to characterize fluid flows in which there are simultaneous momentum and mass diffusion convection processes, so that the concentration boundary layer decreases with an increase in Schmidth number.

Fig 11 shows the chemical reaction parameter, it is noticed that concentration decreases as chemical reaction parameter increases.

Fig 12 shows that the effect of Eckert number, it is observed that concentration decreases as Eckert number increases.

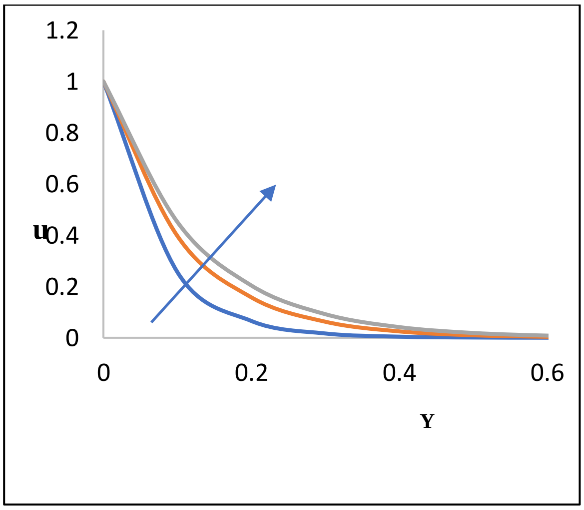


Fig.1 Velocity profile for various values of K=0.1,0.4,3.0,a=t=1.0,M=3.0,Gr=Gc=5.0, Q=R=Kr=0.1, Pr=0.71,Sc=0.22

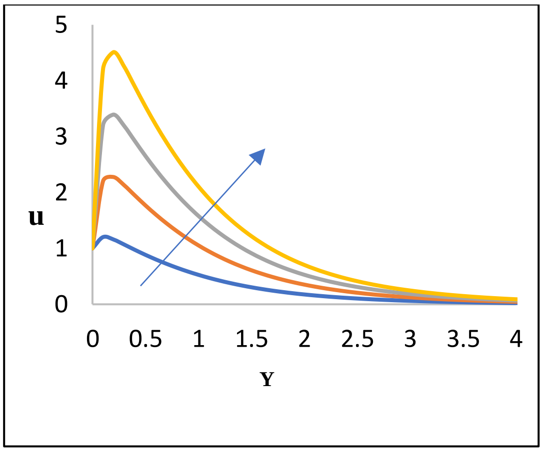


Fig.2 Velocity Profile for various values of Gr=5,10,15,20, Q=R=K=Kr=0.1, a=t=1.0,M=3.0, Gc=5.0,Pr=0.71,Sc=0.96

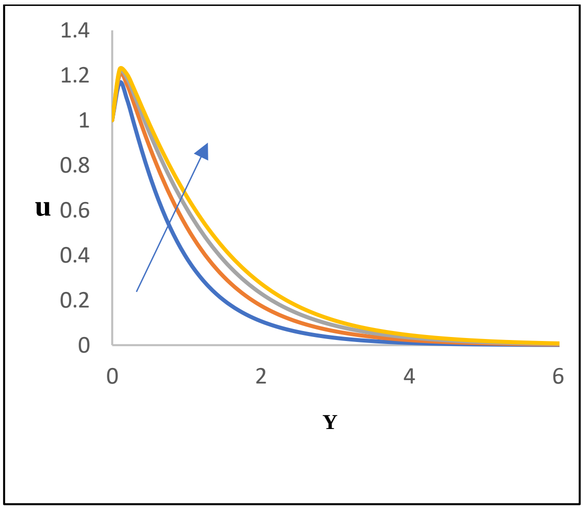


Fig.3 Velocity profile for various values of Gc=5,10,15,20, Gr=5,a=t=1.0,M=3.0, Q=K=Kr=R=0.1, Sc=0.22,Pr=0.71

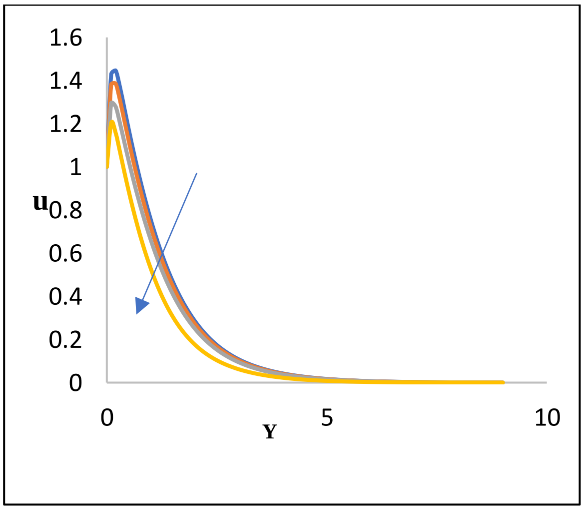


Fig.4 Velocity profile for various values of M=0.5,1.0.2.0,3.0,a=t=1.0,Pr=0.71, Sc=0.48,Gr=Gc=5.0, K=Kr=R=Q=0.1

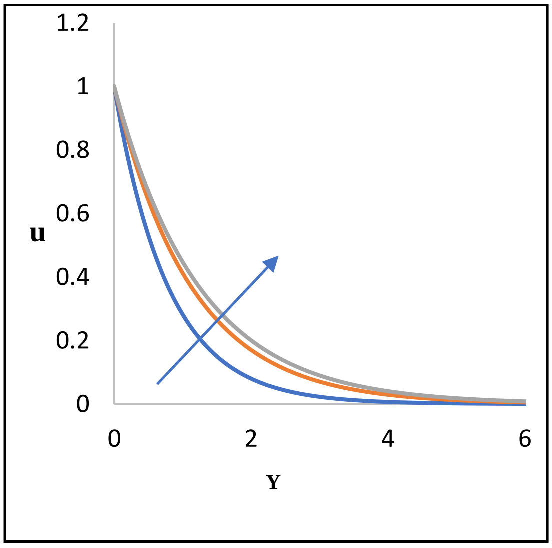


Fig.5 Velocity profile for various values of Ec=0.1,0.5,3.5, K=0.5,Q=R=Kr=0.1,Gr=Gc=5.0, M=3.0, a=t=1.0,Sc=0.22,Pr=0.71

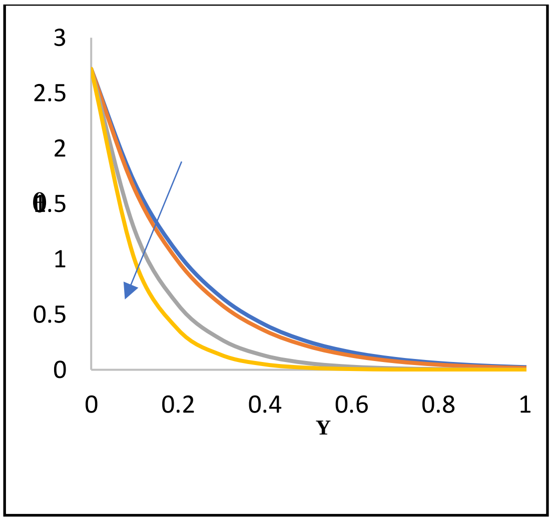


Fig.6 Temperature profile for various values of R=0.1,0.7,5.0,9.0, M=3.0,Gr=Gm=5, K=Kr=Q=0.1, a=t=1.0,Sc=Pr=0.71

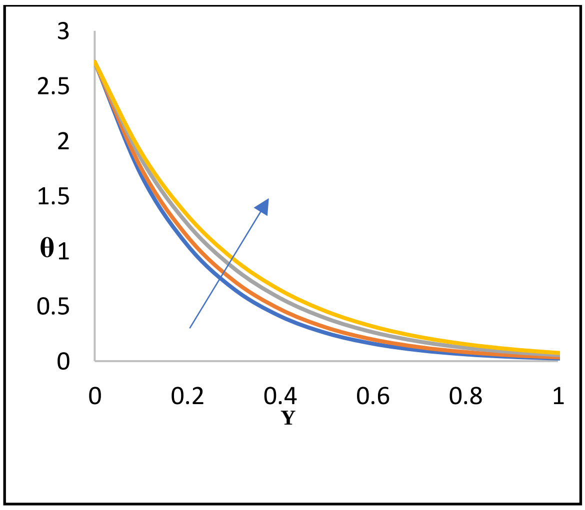


Fig.7 Temperature profile for various values of Q=0.1,0.7,1.5,2.0,Sc=Pr=0.71,R=K=Kr=0.1, M=3.0, a=t=1.0,Gr=Gc=5.0

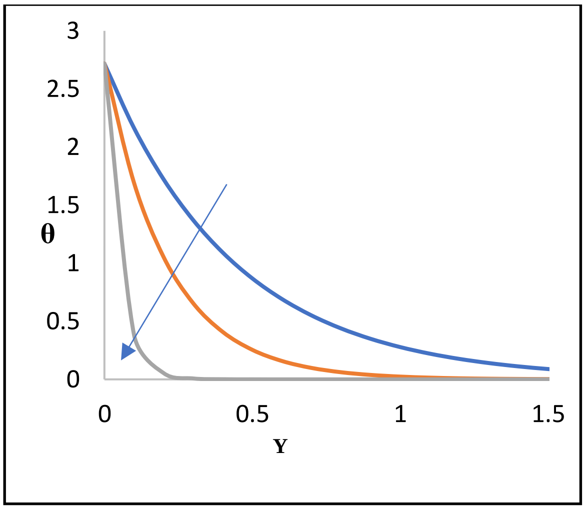


Fig.8 Temperature profile for various values of Pr=0.3,0.71,7.1, a=t=1.0,M=3.0,Sc=0.71, Gr=Gc=5.0, Q=R=K=Kr=0.1

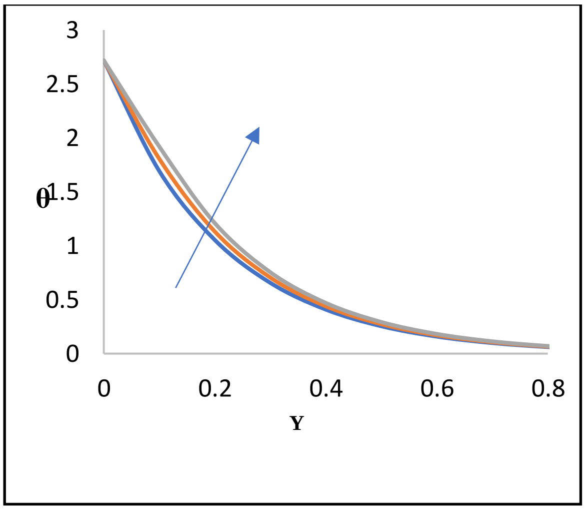


Fig.9 Temperature profile for various values of Ec=0.0001,0.0007,0.1, Pr=Sc=0.71,a=t=1.0, Gr=Gc=3.0,R=K=Kr=Q=0.1

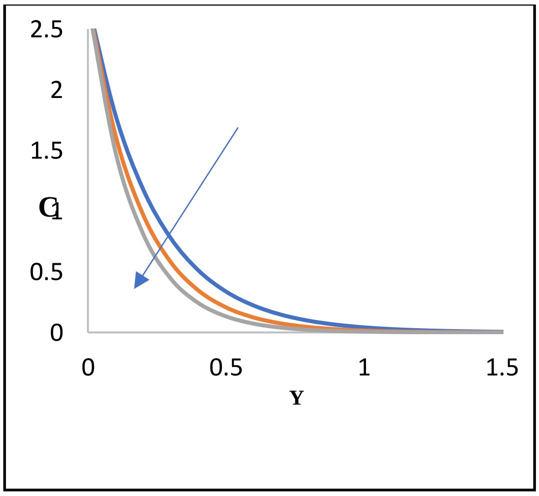


Fig.10 Concentration profile for various values of Sc=0.60,0.78,0.96,r=0.71,a=t=1.0,K=Kr=Q=R=0.1,M=3.0,Gr=Gc=50

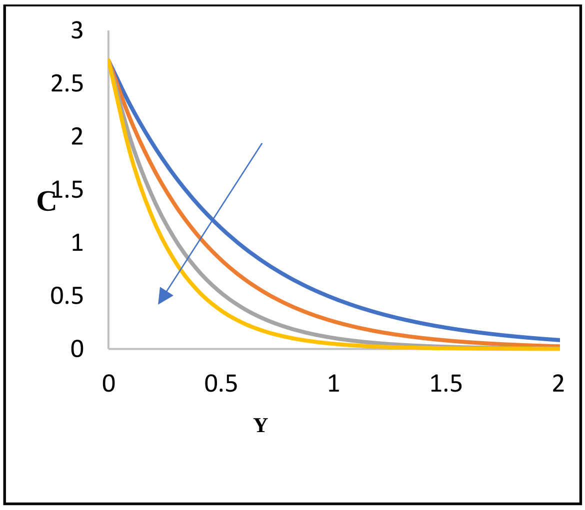


Fig.11 Concentration profile of various values of Kr=0.1,0.7,1.5,2.0,R=Q=K=0.1,M=3.0, a=t=1.0, Pr=0.71,Gr=Gc=5.0

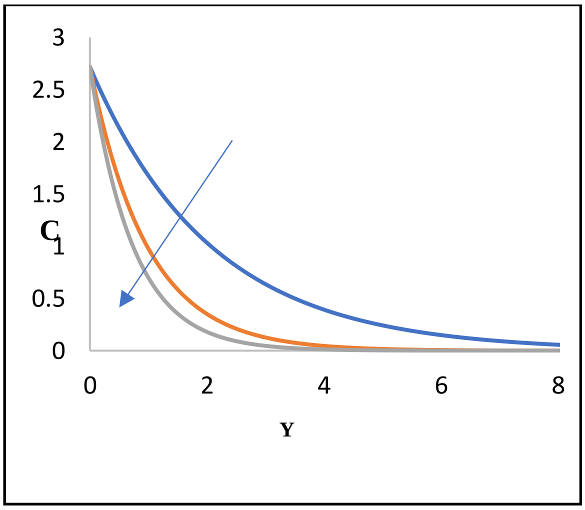


Fig.12 Concentration profile for various values of Ec=0.5,1.5,3.0, Pr=Sc=0.92,a=t=1.0, Gr=Gc=3.0,M=3.0,Q=R=K=Kr=0.1

5. Tables

M	Gr	Gc	K	Sc	Pr	Kr	Q	R	τ	
									Appidi L (24)	Present study
0.2	0.2	0.2	0.1	0.22	0.71	0.9	0.7	0.8	0.50751758	0.50751760
0.23	0.2	0.2	0.15	0.96	0.71	0.9	0.7	0.8	0.42229164	0.42229162
0.3	0.5	0.5	0.23	0.78	0.71	0.9	0.7	0.8	0.27157485	0.27157488
0.3	0.3	0.3	0.27	0.78	0.71	0.9	0.7	0.8	0.29112482	0.29112480
0.5	0.2	0.3	0.3	0.78	0.71	0.9	0.7	0.8	0.30960953	0.30960955
0.5	0.5	0.5	0.3	0.78	0.71	0.9	0.7	0.8	0.22847712	0.22847714
0.5	0.2	0.2	0.4	0.99	0.71	0.9	0.7	0.8	0.26683104	0.26683104

Pr	R	Q	Nu	
			Appidi L (24)	Present study

0.4	0.1	0.1	0.09248495	0.09248496
0.6	0.2	0.1	0.17016983	0.17016985
0.65	0.1	0.2	0.08935261	0.08935262
0.71	0.2	0.3	0.09929514	0.09929514
0.78	0.1	0.2	0.11028004	0.11028004
0.84	0.2	0.4	0.07662249	0.07662250
0.96	0.3	0.2	0.21301460	0.21301460
0.98	0.2	0.1	0.21513414	0.21513414
1.5	0.5	0.4	0.26314926	0.26314928

Sc	Kr	Sh	
		Appidi L (24)	Present study
0.22	0.9	0.213604	0.213602
0.60	0.9	0.3428	0.3432
0.78	0.9	0.40619	0.40620
0.96	0.9	0.46015	0.46016
0.22	0.1	0.06786	0.06786
0.22	0.3	0.09135	0.09138
0.22	0.5	0.11436	0.11436
0.22	0.7	0.13691	0.13692
0.84	0.9	0.42507	0.42508
0.59	0.3	0.20149	0.20150

6. Conclusions:

An analytical study of the effects of chemical reaction andthermal radiation on temperature and concentration on MHD free convection flow past a vertical porous plate in the presence of heat source parameter has been examined. The prevailing equations for the velocity, temperature as well as concentration are solved by utilizing perturbation method at dimensionless parameters.

The present study concludes the following

- In the velocity field fluid flow increasing where the permeability parameter, Grashof number and modified Grashof number increases.
- Velocity profile decreases with the effect of magnetic parameter in flow fluid
- The temperature fluid flow at any point of the flow decreases as if there is an increasing of radiation parameter and Prandtl number.
- Temperature field increases with increasing rate of heat source parameter in the fluid flow
- Concentration profile decreases with increasing of chemical reaction parameter and Schmidth number
- Concentration decreases with effect of increasing Eckert number in the fluid flow
- The velocity, temperature rises with the increasing effect of Eckert number.

Nomenclature:

u^* - Velocity component along x^*-axis

u non-dimensional velocity

T^*- Temperature of the fluid

T_∞^* Temperature of the fluid at infinity

T_w^* Temperature of plate

θ Non-dimensional Temperature

C^* Species concentration of the fluid

C_∞^* Concentration of the fluid at infinity

C Non-dimensional Species concentration

C_w^* Concentration of plate

t Non-dimensional time

t^* time

g Acceleration due to gravity
B_0 Magnetic field component along y^*
K Porosity parameter
K_{p^*} Permeability of medium
k Thermal diffusivity
C_p Specific heat at constant pressure
β Volumetric coefficient of expansion for
D Molecular diffusivity
heat transfer
β^* Volumetric coefficient of expansion with
Q heat source parameter
species concentration
Q_0 Volumetric heat absorption
M Magnetic parameter
G_c Modified Grashof number
G_r Grashof number for heat transfer
P_r Prandtl number
R Radiation parameter
S_cSchmidth number
N_u Nusselt numeral
S_h Sherwood numeral
K_r Chemical reaction parameter
K_{r^*} Chemical molecular diffusivity
E_c Eckert numeral
ρ Density of the fluid
σ Electrical conductivity of the fluid
τ Skin friction
ν Kinematic coefficient of viscosity

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Appendix:

$$N = (M + \frac{1}{K}) \text{ and } F = (Q + R)$$

$$m_1 = \sqrt{Kr\,Sc}, m_2 = \sqrt{F}, m_3 = -\sqrt{N}, m_4 = \sqrt{\Pr(F+N)},$$

$$m_5 = \sqrt{M+a}, S_1 = \frac{Gc}{m_1^2 - N}, S_2 = \frac{Gr}{m_2^2 - N}, S_3 = (1 + S_1 + S_2),$$

$$S_4 = \frac{S_3^2 m_3^2}{4m_3^2 - \Pr(F+N)}, S_5 = \frac{S_2^2 m_2^2}{4m_2^2 - \Pr(F+N)},$$

$$S_6 = \frac{S_1^2 m_1^2}{4m_1^2 - \Pr(F+N)}, S_7 = \frac{2m_2 m_3 S_2 S_3}{(m_2+m_3)^2 - \Pr(F+N)},$$

$$S_8 = \frac{2m_1 m_3 S_1 S_3}{(m_1+m_3)^2 - \Pr(F+N)}, S_9 = \frac{2m_1 m_2 S_1 S_2}{(m_1+m_2)^2 - \Pr(F+N)},$$

$$S_{10} = (-S_4 - S_5 - S_6 + S_7 + S_8 - S_9), S_{11} = \frac{S_{10}}{m_4^2 - (M+a)},$$

$$S_{12} = \frac{S_4}{m_3^2 - (M+a)}, S_{13} = \frac{S_5}{m_2^2 - (M+a)}, S_{14} = \frac{S_6}{m_1^2 - (M+a)},$$

$$S_{15} = \frac{S_7}{(m_1+m_3)^2 - \Pr(F+N)}, S_{16} = \frac{S_8}{(m_2+m_3)^2 - \Pr(F+N)},$$

$$S_{17} = \frac{S_9}{(m_1+m_2)^2 - \Pr(F+N)}, S_{18} = (-S_{11} - S_{12} - S_{13} - S_{14} + S_{15} + S_{16} - S_{17})$$

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