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Soret and Dufour Effect of Unsteady MHD Free Convective Flow of Kuvshinski Fluid with Heat and Mass Transfer

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ABSTRACT

An analytical study of this paper deals with soret and dufour effect of unsteady MHD flow of Kuvshinski fluid with heat and mass transfer. A uniform magnetic field is applied perpendicular to the flow in the porous medium. The expressions for velocity, temperature and concentration are solved. The coefficient of skin friction, heat and mass transfer in terms of nusselt number and Sherwood number are also derived. Results are discussed and analysed for various parameters through graphs.

Keywords: Kuvshinski fluid, MHD, thermal radiation, chemical reaction.

1. INTRODUCTION

Convective flow is an important method of heat and mass transfer under the influence of a magnetic field, thermal radiation and chemical reaction. The wide range of technological aspects has stimulated considerable amount of interest in the study of heat and mass transfer in the convective flow. Possible application of this type of flow can be found in many industries. For example in the power industry among the methods of generation electric power is one in which electrical energy is extracted directly from a moving conducting fluids. Many practical diffusive operations involve the molecular diffusion in the presence of chemical reaction within or at the boundary. Dubey and Bhattacharya[1] examine the flow of viscoelastic fluid past an infinite flat plate with uniform suction. Shvets and Vishevskiy[2] effect of dissipation on convective heat transfer in flow of non-newtonian fluids. Ezzat Magdy[3] study the flow of an unsteady incompressible electrically conducting viscous non-newtonian fluid past a hot infinite porous plate with the periodically alternating suction-injection of the fluid in the presence of transverse uniform magnetic field. Hayat, Nadeem, and Asghar[4] solved the analytically for the flows of viscoelastic fluids are constructed. The flows are induced by general periodic oscillations of a plate. Based on the flow conditions described, three flow situations are solved by Fourier transform. Gireesh Kumar and Raman Krishna[5] studied the analytical effect of mass transfer and chemical reaction on radiation in magnetohydrodynamics convective flow of Kuvshinski fluid. Om Prakash, Devendra kumar and Dwivedi[6] studied analytically MHD free convective flow of a visco elastic (Kuvshinski type) dusty gas through a semi- infinite plate moving with velocity decreasing exponentially with time and radiative heat transfer. Aravind kumar sharma and Dubey and Varshney[7] analysis the effect of kuvshinski fluid on double-diffusive convection-radiation interaction on unsteady MHD flow over a vertical moving porous plate with heat generation and soret effect. Agrawal *et al*.,[8] solved the paper analytically effect of stratified kuvshinski fluid on MHD free convective flow past a vertical porous plate with heat and mass transfer. Gurudatt Sharma and Varshney[9] Stratified kuvshinski fluid effect on MHD free convection flow with heat and mass transfer past a vertical porous plate. Devasena. Leela Ratnam[10] analyse the combined influence of chemical reaction, thermo diffusion and dissipation on convective heat and mass transfer flow of a Kuvshinski fluid past a vertical plate embedded in a porous medium. The solution of the paper consisting of harmonic and non-harmonic solutions. Vidyasagar *et al*.,[11] studied about the boundary layer flow.This paper carried out for incompressible, viscous, radiating and chemically reacting Kuvshinski fluid through a porous medium past a vertical infinite plate. Reddy *et al*.,[12] investigates the Unsteady MHD free convection flow of a kuvshinski fluid past a vertical porous plate in the presence of chemical reaction and heat source/sink. Mohammed Ibrahim and Suneetha[13] gave an analytical result on thermal radiation in the surface during heat transfer. Influence of chemical reaction and heat source on MHD free convection boundary layer flow of radiation absorbing Kuvshinski fluid in porous medium. Lalitha *et al*.,[14] analysis the influence of diffusion thermo, chemical reaction and viscous dissipation on hydro-magnetic free convective heat and mass transfer flow. Krishna Reddy *et al*.,[15] investigate the MHD free convective flow of viscoelastic fluid. The Rosseland approximation is used to describe the radiative heat flux in energy equation. Praveena *et al*.,[16] analysis the Kuvshinski fluid through MHD convective heat transfer flow of kuvshinski fluid past an infinite moving plate embedded in a porous medium with thermal radiation temperature dependent heat source and variable suction. Sivakumar Narasu and Rushi Kumar[17] investigate the diffusion-thermo effects on unsteady combined convection magnetohydromagnetic boundary layer flow of viscous electrically conducting and chemically reacting fluid over a vertical permeable radiated plate embedded in a highly porous medium. El-Dabe *et al*.,[18] analysis has been developed to investigate the effect of thermophoresis on unsteady flow. The fluid is obeying to Kuvshinski model and is stressed by uniform magnetic field. The non-linear partial equations can be solved by perturbation technique.

2. MATHEMATICAL FORMULATION

Consider a two-dimensional unsteady MHD free convective flow of a viscous incompressible radiating chemically reacting heat generation/absorption of Kuvshinski fluid past a porous medium in the semi-infinite plate. Consider x^* axis along the porous plate in upward direction and y^* axis normal to it. The induced magnetic field is neglected as the magnetic Reynolds number of the flow is very small, so that the produced magnetic field is insignificant. Also it is supposed that there is no applied voltage, so that the electric field is vanished. The plate is assumed to be electrically non-conducting with uniform magnetic field B_0 is applied normal to the plate. It is assumed that initially the plate and the fluid are at same temperature and concentration in the entire region of the fluid. Under the above assumptions the flow field is governed by the conservation of momentum, energy and species equation.

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1}$$

$$\rho\left\{\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)\frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*}\right\} = -\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)\frac{\partial p^*}{\partial x^*} + \mu\frac{\partial^2 u^*}{\partial y^{*2}} - \rho g - \left(\sigma B_0{}^2 + \frac{\mu}{K^*}\right)\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)u^* \tag{2}$$

$$\frac{\partial T^*}{\partial t^*} + v^*\frac{\partial T^*}{\partial y^*} = \frac{k}{\rho C_p}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{R_0}{\rho C_p}(T^* - T_\infty{}^*) - \frac{1}{\rho C_p}\frac{\partial q_r{}^*}{\partial y^*} + \frac{\vartheta}{C_p}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{D_M K_T}{\rho C_p}\frac{\partial^2 C^*}{\partial y^{*2}} \tag{3}$$

$$\frac{\partial C^*}{\partial t^*} + v^*\left(\frac{\partial C^*}{\partial y^*}\right) = D\frac{\partial^2 C^*}{\partial y^{*2}} - Kc(C^* - C_\infty{}^*) + D_T\frac{\partial^2 T^*}{\partial y^{*2}} \tag{4}$$

The boundary conditions at the wall in the free stream are:

$$u^* = u_p{}^* + L_1\frac{du^*}{dy^*},\ T^* = T_w{}^* + \varepsilon A_T(T_w{}^* - T_\infty{}^*)e^{n^*t^*},\ C^* = C_w{}^* + \varepsilon A_T(C_w{}^* - C_\infty{}^*)e^{n^*t^*}\ at \quad y^* = 0$$

$$u^* = 0\ T^* \to T_\infty{}^*\ C^* \to C_\infty{}^*\ as \quad y^* \to \infty \tag{5}$$

where A_T is a constant taking value 0 or 1.

where u^*, v^*- velocity components in X, Y directions respectively, g- gravitational acceleration, t^*- time, ϑ- kinematic coefficient of viscosity, σ- electrical conductivity, μ- the viscosity, ρ- density of the fluid, $\alpha_1{}^*$ - the coefficient of kuvshinski fluid, T^* - temperature of the fluid, $T_w{}^*$ - the temperature at the plate, $T_\infty{}^*$ - the temperature of fluid in free stream, k - thermal conductivity, C_p - specific heat at constant pressure, $q_r{}^*$ - radiative heat flux, K^* - permeability parameter of the porous medium, $u_p{}^*$ - in the direction of fluid flow, and the free stream velocity $U_\infty{}^*$ follows the exponentially increasing small perturbation law, Kc - chemical reaction, D_T - thermal diffusivity, S_c - Schmidt number, S_0 - Soret number, D_M - chemical molecular diffusivity.

$$v^* = -V_0\left(1 + \varepsilon A e^{n^*t^*}\right)$$

where, A is a real positive constant, ε and εA are small less than unity and V_0 is a scale of suction velocity which has non-zero positive constant.

$$\rho\frac{dU_\infty{}^*}{dt^*} = -\frac{\partial p^*}{\partial x^*} - \rho_\infty g - \sigma B_0{}^2 U_\infty{}^* - \frac{\mu}{K^*}U_\infty{}^* \tag{6}$$

Eliminating $\frac{\partial p^*}{\partial x^*}$

$$\rho\left\{\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)\frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*}\right\} = \rho\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)\frac{dU_\infty{}^*}{dt^*} + \mu\frac{\partial^2 u^*}{\partial y^{*2}} + (\rho_\infty - \rho)g + \left(\sigma B_0{}^2 + \frac{\mu}{K^*}\right)\left(1+\alpha_1{}^*\frac{\partial}{\partial t^*}\right)(U_\infty{}^* - u^*) \tag{7}$$

By making use the equation of state

$(\rho_\infty - \rho) = \beta(T^* - T_\infty{}^*) + \beta^*(C^* - C_\infty{}^*)$

where, β is the volumetric coefficient of thermal expansion and ρ_∞ is the density of the fluid far away the surface.

$$\left(1 + \alpha_1{}^* \frac{\partial}{\partial t^*}\right)\frac{\partial u^*}{\partial t^*} + v^* \frac{\partial u^*}{\partial y^*} = \left(1 + \alpha_1{}^* \frac{\partial}{\partial t^*}\right)\frac{dU_\infty{}^*}{dt^*} + \mu \frac{\partial^2 u^*}{\partial y^{*2}} + g\beta(T^* - T_\infty{}^*) + g\beta(C^* - C_\infty{}^*) + \left(\sigma B_0{}^2 + \frac{\mu}{K^*}\right)\left(1 + \alpha_1{}^* \frac{\partial}{\partial t^*}\right)(U_\infty{}^* - u^*) \quad (8)$$

The radiation flux on the basis of the Rosseland diffusion model for radiation heat transfer is expressed as

$$q_r{}^* = -\frac{4\sigma^*}{3k_1{}^*}\frac{\partial T^{*4}}{\partial y^*}$$

where, σ^* and $k_1{}^*$ are respectively Stefan-Boltzmann constant and the mean absorption coefficient. We assume that the temperature difference within the flow are sufficiently small such that T^{*4} may be expressed as a linear function of the temperature. This is accomplished by expanding in Taylor series about $T_\infty{}^*$ and neglecting higher order terms,

$$T^{*4} \cong 4T_\infty{}^{*3}T^* - 3T_\infty{}^{*4}$$

$$\frac{\partial T^*}{\partial t^*} + v^* \frac{\partial T^*}{\partial y^*} = \frac{k}{\rho C_p}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{R_0}{\rho C_p}(T^* - T_\infty{}^*) + \frac{16\sigma^* T_\infty{}^{*3}}{3\rho C_p k_1{}^*}\frac{\partial^2 T^{*2}}{\partial y^{*2}} + \frac{\vartheta}{C_p}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{D_M K_T}{\rho C_p}\frac{\partial^2 C^*}{\partial y^{*2}} \quad (9)$$

Introducing the non-dimensional variables,

$$u = \frac{u^*}{U_0}, v = \frac{v^*}{V_0}, y = \frac{y^* V_0}{\vartheta}, U_\infty{}^* = U_\infty U_0, u_p{}^* = U_p U_0, t = \frac{t^* V_0{}^2}{\vartheta}, n = \frac{n^* v}{V_0{}^2}$$

$$\theta = \frac{T^* - T_\infty{}^*}{T_w{}^* - T_\infty{}^*}, \varphi = \frac{C^* - C_\infty{}^*}{C_w{}^* - C_\infty{}^*} \quad (10)$$

Then substituting the non-dimensional form we obtain

$$\left(1 + \alpha_1 \frac{\partial}{\partial t}\right)\frac{\partial u}{\partial t} - (1 + \varepsilon A e^{nt})\frac{\partial u}{\partial y} = \left(1 + \alpha_1 \frac{\partial}{\partial t}\right)\frac{dU_\infty}{dt} + \frac{\partial^2 u}{\partial y^2} + G_r\theta + G_c\varphi + N\left(1 + \alpha_1 \frac{\partial}{\partial t}\right)(U_\infty - u) \quad (11)$$

$$Pr\frac{\partial \theta}{\partial t} - Pr(1 + \varepsilon A e^{nt})\frac{\partial \theta}{\partial y} = \left(1 + \frac{4R}{3}\right)\frac{\partial^2 \theta}{\partial y^2} + \Pr(\gamma)\theta + EPr\left(\frac{\partial u}{\partial y}\right)^2 + PrDf\frac{\partial^2 \varphi}{\partial y^2} \quad (12)$$

$$\frac{\partial \varphi}{\partial t} - (1 + \varepsilon A e^{nt})\frac{\partial \varphi}{\partial y} = \frac{1}{S_c}\frac{\partial^2 \varphi}{\partial y^2} - Kc\varphi + S_0\frac{\partial^2 \theta}{\partial y^2} \quad (13)$$

Where

$$G_r = \frac{\vartheta g\beta(T_w{}^* - T_\infty{}^*)}{V_0{}^2 U_0}, M = \frac{\sigma B_0{}^2\vartheta}{\rho V_0{}^2}, K = \frac{K^* V_0{}^2}{\vartheta^2}, \gamma = \frac{\vartheta R_0 K^*}{\rho V_0{}^2 C_p}, R = \frac{4\sigma^* T_\infty{}^{*3}}{k k_1{}^*} Pr = \frac{\rho\vartheta C_p}{k}, \alpha_1 = \frac{\alpha_1{}^* V_0{}^2}{\vartheta}, \; N = \left[M + \frac{1}{K}\right], S_c = \frac{v}{D}, E = \frac{v_0{}^2}{C_p(T_w{}^* - T_\infty{}^*)}, \; D_f = \frac{D_M K_T(C_w{}^* - C_\infty{}^*)}{\rho C_p(T_w{}^* - T_\infty{}^*)}, S_0 = \frac{D_T v(C_w{}^* - C_\infty{}^*)}{V_0{}^2},$$

$$G_m = \frac{\vartheta g\beta(C_w{}^* - C_\infty{}^*)}{V_0{}^2 U_0}$$

The corresponding boundary conditions are

$$u = u_p + h_1\frac{du}{dy}, T = 1 + \varepsilon A_T e^{nt}, C = 1 + \varepsilon A_T e^{nt} \; at \quad y = 0$$

$$u \to 0, T \to 0, C \to 0 \; as \quad y \to \infty \quad (14)$$

3. METHOD OF SOLUTION

In order to reduce the system of partial differential equation to ordinary differential equations in non-dimensional form, we consider

$$\left.\begin{aligned} u &= u_0(y) + \varepsilon e^{nt} u_1(y) + O(\varepsilon^2) \\ \theta &= \theta_0(y) + \varepsilon e^{nt} \theta_1(y) + O(\varepsilon^2) \\ \varphi &= \varphi_0(y) + \varepsilon e^{nt} \varphi_1(y) + O(\varepsilon^2) \end{aligned}\right\} \quad (15)$$

Substituting the above equation (15) into the equations (11) - (13) and equating the coefficients in (15), we get

$$u_0'' + u_0' - Nu_0 = -(N + Gr\theta_0 + Gc\varphi_0) \quad (16)$$

$$u_1'' + u_1' - (N+n)(1+\alpha_1 n)u_1 = -(1+n\alpha_1)(N+n) - Au_0' - Gr\theta_1 - Gc\varphi_1 \quad (17)$$

$$(3+4R)\theta_0'' + 3Pr\theta_0' + 3Pr\gamma\theta_0 = 0 \quad (18)$$

$$(3+4R)\theta_1'' + 3Pr\theta_1' - 3Pr(n-\gamma)\theta_1 = -3PrEu_0'^2 - 3APr\theta_0' - 3PrDf\varphi_0'' \quad (19)$$

$$\varphi_0'' + S_c\varphi_0' - S_cKc\varphi_0 = -S_cS_0\theta_0'' \quad (20)$$

$$\varphi_1'' + S_c\varphi_1' - S_c(n+Kc)\varphi_1 = -AS_c\varphi_0' - S_cS_0\theta_1'' \quad (21)$$

The corresponding boundary conditions are

$$u_0 = u_p + h_1\frac{du_0}{dy}, u_1 = h_1\frac{du_1}{dy}, \theta_0 = 1, \theta_1 = A_T, \varphi_0 \to 1, \varphi_1 \to A_T \ at \qquad y = 0$$

$$u_0 \to 0, u_1 \to 0, \theta_0 \to 0, \theta_1 \to 0, \varphi_0 \to 0, \varphi_1 \to 0 \ as \qquad y \to \infty \quad (22)$$

The equations from (16) - (21) are second order linear differential equations with constant coefficients. The solutions of these paired equations under the corresponding boundary conditions (22) and we get the expression for velocity, temperature and concentration as

$$u(y,t) = [P_1e^{-r_3y} + 1 + (H_2+H_4)e^{-r_1y} + H_3e^{-r_2y}] + \varepsilon e^{nt}[P_4e^{-r_6y} + 1 + H_{18}e^{-r_3y} + (H_{19}+H_{25}+H_{29})e^{-r_1y} + (H_{20}+H_{26}+H_{28})e^{-r_2y} + (H_{21}+H_{30})e^{-r_4y} + (H_{22} + R_{31})e^{-2r_3y} + (H_{23}+H_{32})e^{-2r_1y} + (H_{24}+H_{33})e^{-2r_2y}] \quad (23)$$

$$\theta(y,t) = e^{-r_1y} + \varepsilon e^{nt}[H_2e^{-r_4y} + H_5e^{-2r_3y} + H_6e^{-2r_1y} + H_7e^{-2r_2y} + (H_8 + H_{10})e^{-r_1y} + H_9e^{-r_2y}] \quad (24)$$

$$\varphi(y,t) = [(1-H_1)e^{-r_2y} + H_1e^{-r_1y}] + \varepsilon e^{nt}[H_3e^{-r_5y} + H_{11}e^{-r_2y} + (H_{12}+H_{17})e^{-r_1y} + H_{13}e^{-r_4y} + H_{14}e^{-2r_3y} + H_{15}e^{-2r_1y} + H_{16}e^{-2r_2y}] \quad (25)$$

Skin friction

From the velocity field, the Skin friction (τ) coefficient at the surface y=0 is

$$\tau = -\left(\frac{\partial u}{\partial y}\right)_{y=0} = [P_5] + \varepsilon e^{nt}[P_6] \quad (26)$$

Nusselt number

From the temperature field, the rate of heat transfer between plate and the fluid can be expressed in terms of non-dimensional Nusselt number (N_u) is

$$N_u = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = r_1 + \varepsilon e^{nt}[P_7] \quad (27)$$

Sherwood number

From the concentration field, the rate of mass transfer between plate and the fluid can be expressed in terms of non-dimensional Sherwood number (S_h) is

$$S_h = -\left(\frac{\partial \varphi}{\partial y}\right)_{y=0} = P_8 + \varepsilon e^{nt}[P_9] \quad (28)$$

4. RESULT AND DISCUSSION

The impact of soret and dufour effect, heat source/sink, radiation and chemical reaction on unsteady MHD flow of a Kuvshinski fluid through porous plate filled in a channel is analysed. Using different parameters like Grashof number, Schmidt number, soret number, dufour number, prandtl number and so forth, the flow of the fluid can be performed on velocity, temperature and concentration profiles are demonstrated graphically.

Case(i): Plate with variable wall temperature A_T=1 can be discussed from figure 1-16 and it explains the different parameters from velocity, temperature and concentration profile.

Dufour effect has a mass concentration occurring as coupled effect of irreversible process is shown in figure 1 as the dufour value increases and the velocity profile decreases. Figure 2 depicts the radiation parameter increases with the increasing velocity profile. The different values of prandtl number in the velocity profile are shown in the figure 3. In this it is observed that velocity decreases with the increase of prandtl number. Prandtl number is a non-dimensional number which is small, it means heat diffuses fast while compared to the velocity and in the liquid metals the thickness of the thermal boundary layer is more than the velocity boundary layer. Figure 4 signifies the effect of thermal Grashof number on velocity is presented. As Grashof number increases with the increase of velocity because Grashof number depends on the heat transfer in the velocity. In figure 5 explains the permeability parameter in the velocity profile. It is observed that permeability parameter increases as the decrease of velocity. This is because of the measures the ability of porous plate to allow the liquid pass through it. Figure 6 demonstrates the velocity profile with the variation in magnetic parameter. From this it is noted that the range of velocity increases by the decrease of magnetic parameter. The velocity profile for different values of direction of fluid flow in porous plate is shown in figure 7. In this figure the velocity increases with the increase of direction of fluid flow. Figure 8 is noticed that the increase of velocity profile with the increase of viscoelastic parameter. In this viscoelasticity, both the elasticity and viscosity character occurs in the same field. Figure 9 displays the effect of velocity in terms of heat generation parameter value increases the velocity decreases. In figure 10 effect of modified Grashof number increases also the fluid velocity increases. Dufour effect is the energy flux in the temperature gradient is studied in figure 11. From this it is noticed that temperature increases as Dufour effect increases. It is observed from figure 12 that the temperature increases with the increase of radiation parameter because the thermal radiation is associated with high temperature. Figure 13 demonstrates the effect of prandtl number on the temperature profiles with increasing prandtl number the temperature profile decreases. Prandtl number explains the heat transfer of moving fluid and solid particle. Effects of chemical reaction parameter on concentration are presented in figure 14. From this it is noticed that the chemical reaction increases while decrease of concentration. In figure 15 explains the effect of Schmidt number in concentration profile. It is observed that increase of Schmidt number with the increase of concentration profile. The dimensionless concentration profile for various values of soret number is shown in figure 16. From the figure the effect of soret number increases with the decrease of concentration profile.

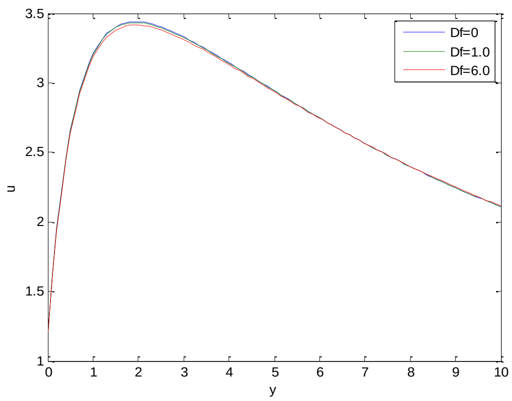

Figure 1: Effect of dufour effect on velocity

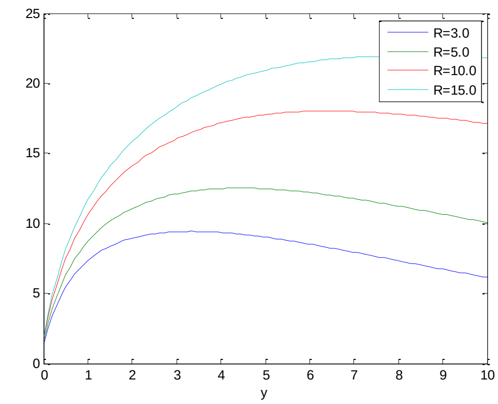

Figure 2: Effect of thermal radiation on velocity

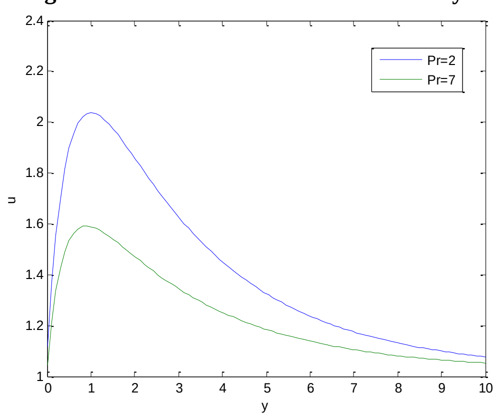

Figure 3: Effect of prandtl number on velocity

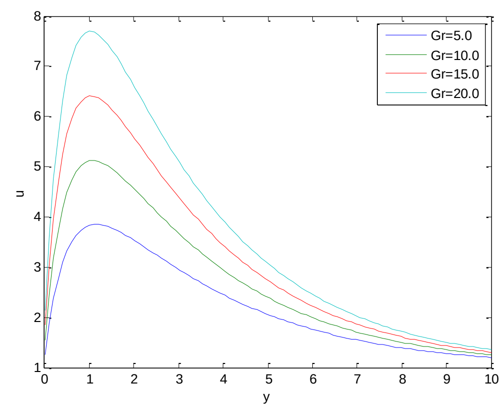

Figure 4: Effect of thermal Grashof number on velocity

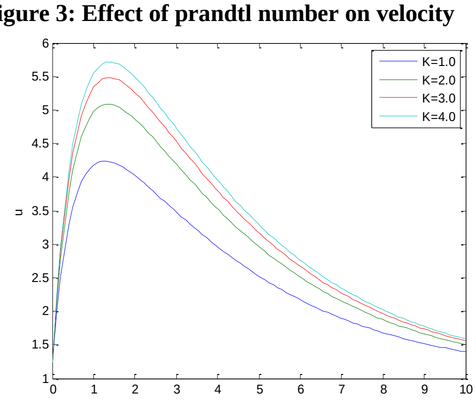

Figure 5: Effect of permeability parameter on velocity

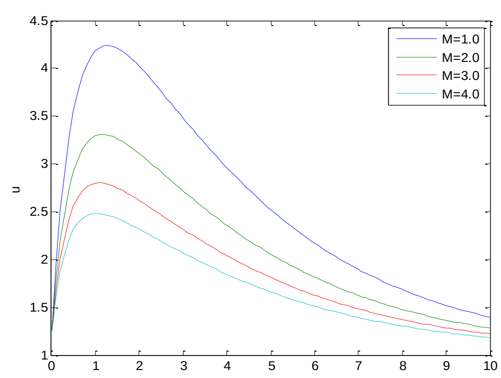

Figure 6:Effect of Magnetic parameter on velocity

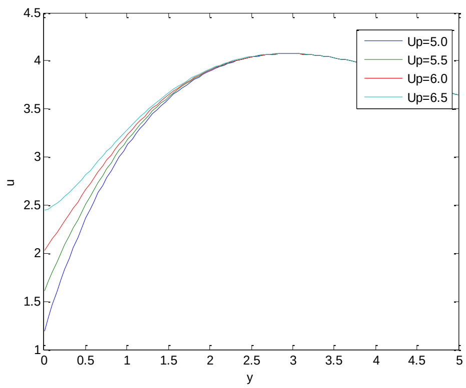

Figure 7:Effect of fluid flow on velocity

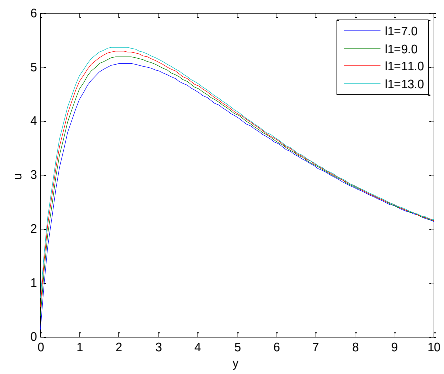

Figure 8:Effect of visco-elastic parameter on velocity

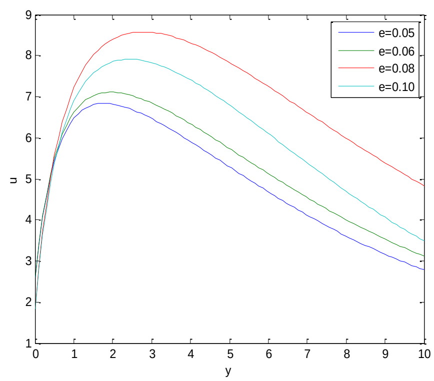

Figure 9:Effect of heat generation on velocity

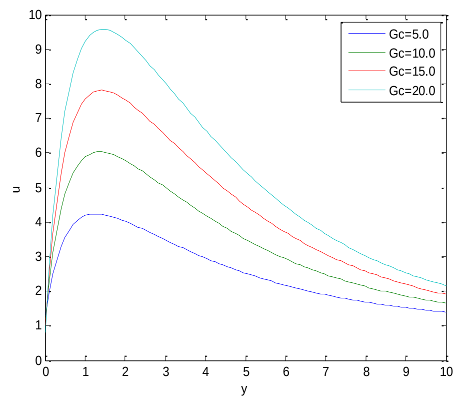

Figure10:Effect of modified grashof number on velocity

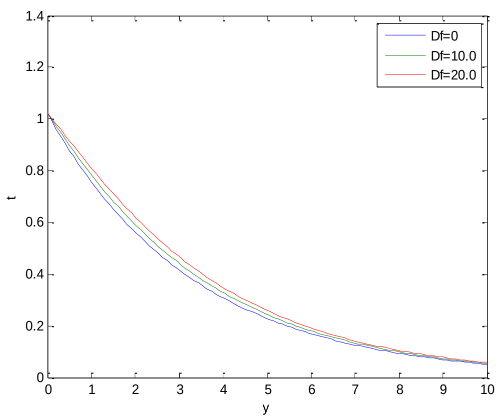

Figure 11: Effect of Dufour number on temperature

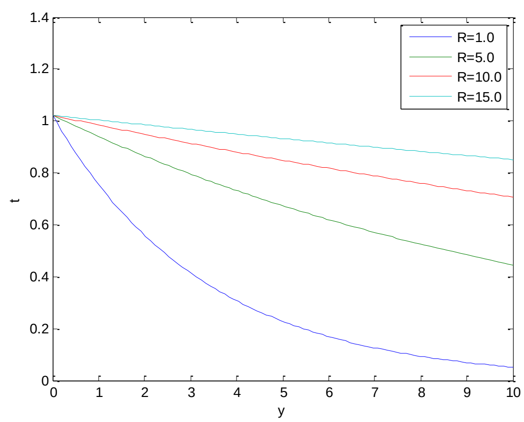

Figure 12: Effect of thermal radiation on temperature

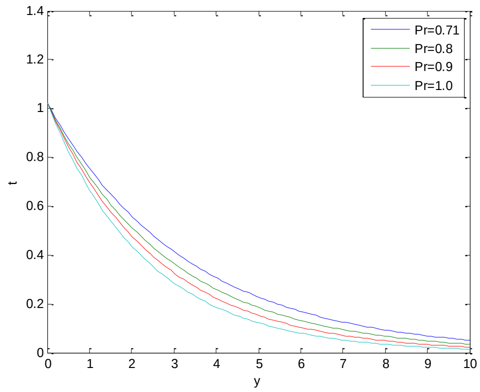

Figure13:Effect of Prandtl number on temperature

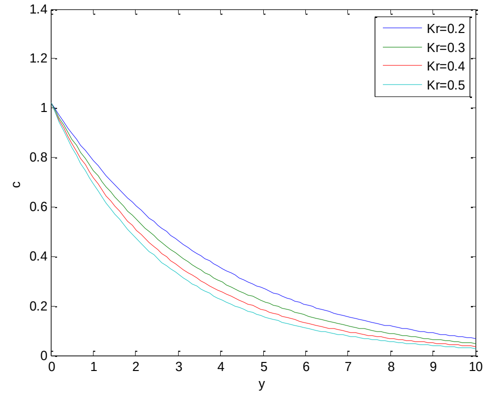

Figure14:Effect of chemical reaction on concentration

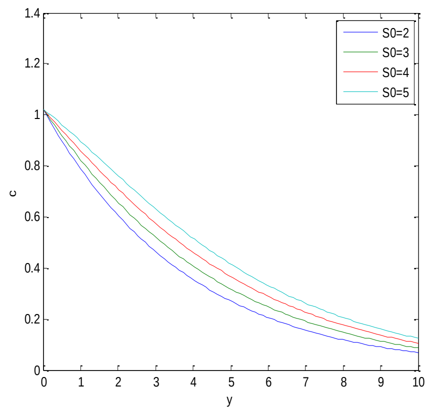

Figure15:Effect of soret number on concentration

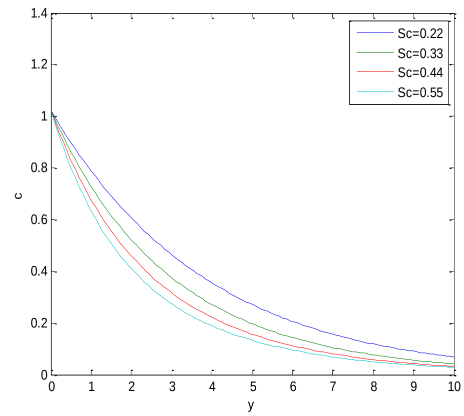

Figure16:Effect of Schmidt number on concentration

Case (ii): Plate with constant wall temperature A_T=0 can be discussed from figure 17-32 and it explains the same variations in the different parameters from velocity, temperature and concentration profile.

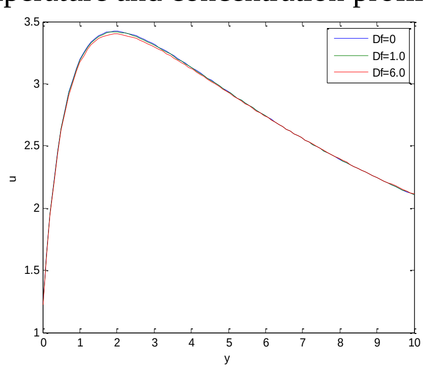

Figure 17: Effect of dufour effect on velocity

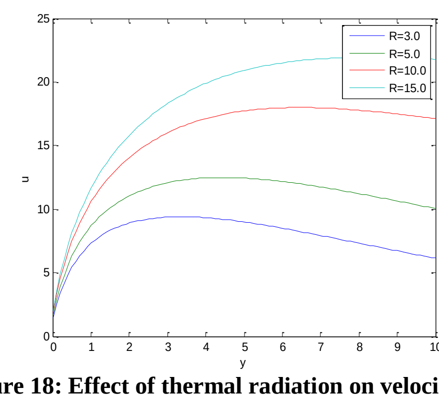

Figure 18: Effect of thermal radiation on velocity

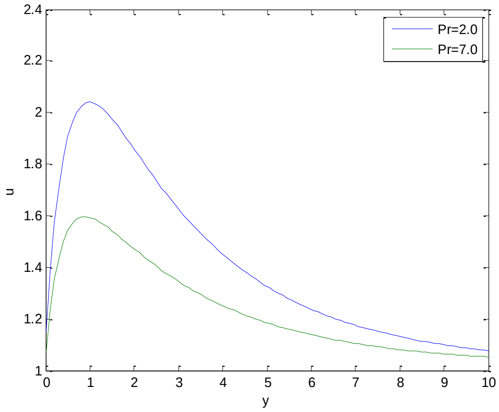

Figure 19: Effect of prandtl number on velocity

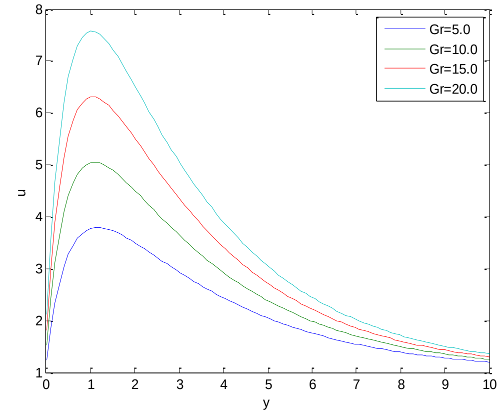

Figure 20: Effect of thermal Grashof number on velocity

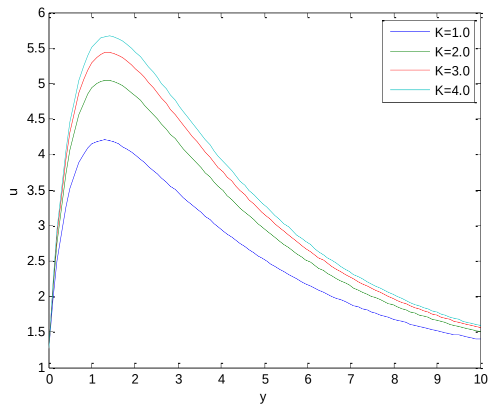

Figure 21: Effect of permeability parameter on velocity

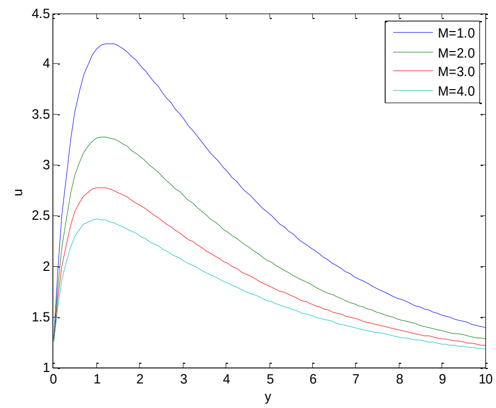

Figure22:Effect of Magnetic parameter on velocity

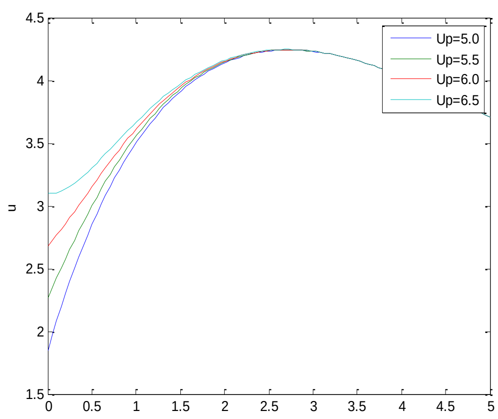

Figure23:Effect of fluid flow on velocity

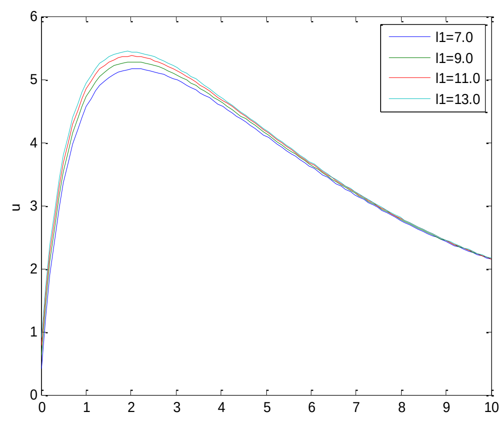

Figure24:Effect of visco-elastic parameter on velocity

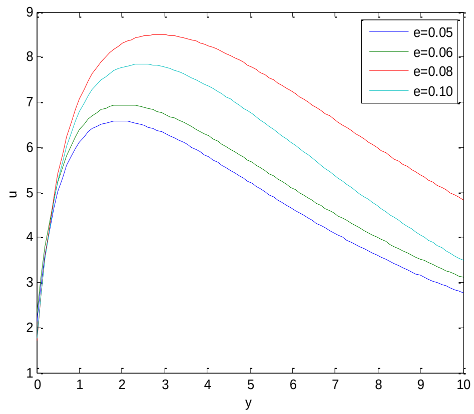

Figure25:Effect of heat generation on velocity

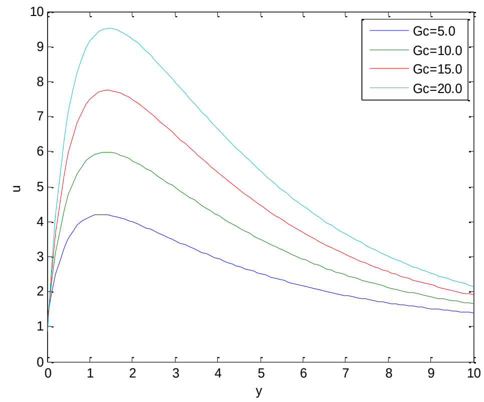

Figure26: Effect of modified Grashof number on velocity

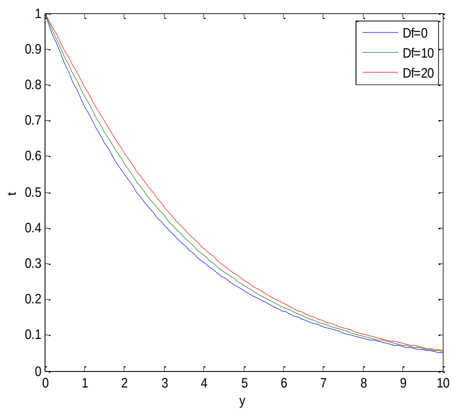

Figure 27: Effect of Dufour number on temperature

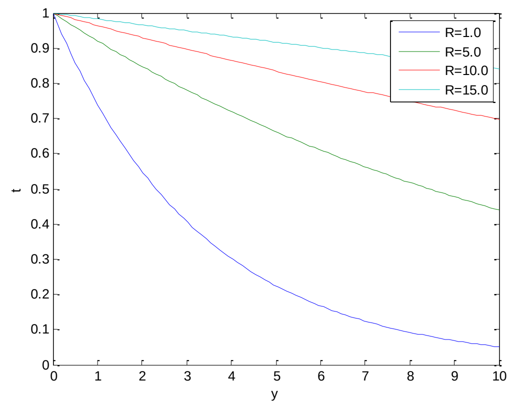

Figure 28: Effect of thermal radiation on temperature

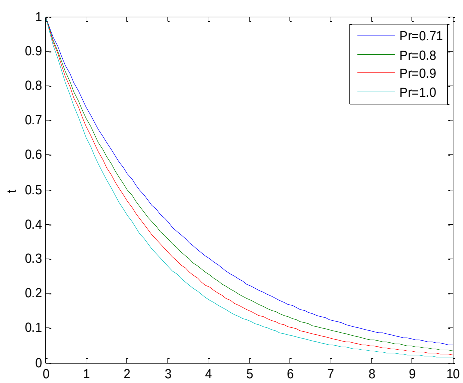

Figure29:Effect of Prandtl number on temperature

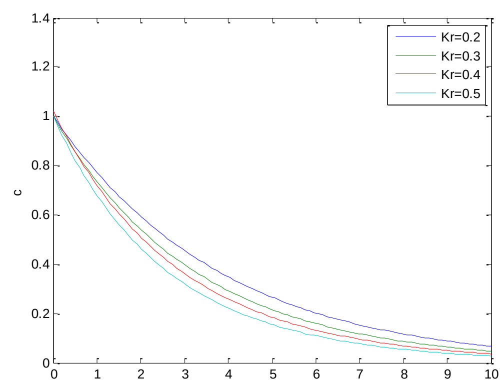

Figure30:Effect of chemical reaction on concentration

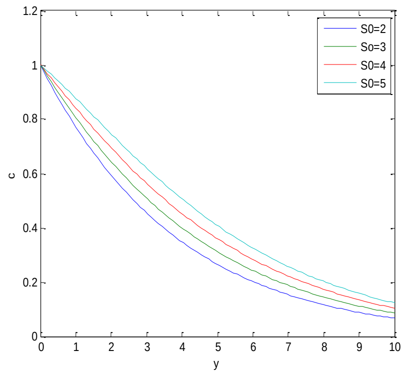

Figure31:Effect of soret number on concentration

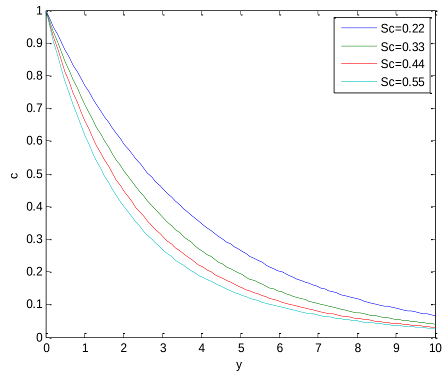

Figure32:Effect of schmidt number on concentration

Table 1: Skin friction at variable and constant wall temperature

R	Pr	Gr	Gc	K	M	Up	λ_1	η	Df	τ (A_T=1)	τ (A_T=0)
3	0.71	5	5	1	1	1	0.01	0.01	0.2	-11.6	-11.33
5	0.71	5	5	1	1	1	0.01	0.01	0.2	-13.16	-12.81
10	0.71	5	5	1	1	1	0.01	0.01	0.2	-15.38	-15.06
15	0.71	5	5	1	1	1	0.01	0.01	0.2	-16.65	-16.36
3	**2**	5	5	1	1	1	0.01	0.01	0.2	-7.18	-6.98
3	**7**	5	5	1	1	1	0.01	0.01	0.2	-6.091	-5.89
3	0.71	**10**	5	1	1	1	0.01	0.01	0.2	-15.39	-15.15
3	0.71	**15**	5	1	1	1	0.01	0.01	0.2	-19.19	-18.87
3	0.71	**20**	5	1	1	1	0.01	0.01	0.2	-22.99	-22.59
3	0.71	5	**10**	1	1	1	0.01	0.01	0.2	-19.42	-19.17
3	0.71	5	**15**	1	1	1	0.01	0.01	0.2	-27.3	-26.96
3	0.71	5	**20**	1	1	1	0.01	0.01	0.2	-35.24	-34.82
3	0.71	5	5	**2**	1	1	0.01	0.01	0.2	-14.79	-14.61
3	0.71	5	5	**3**	1	1	0.01	0.01	0.2	-16.35	-16.15
3	0.71	5	5	**4**	1	1	0.01	0.01	0.2	-17.27	-17.07
3	0.71	5	5	1	**2**	1	0.01	0.01	0.2	-8.25	-8.13
3	0.71	5	5	1	**3**	1	0.01	0.01	0.2	-6.50	-6.39
3	0.71	5	5	1	**4**	1	0.01	0.01	0.2	-5.41	-5.32
3	0.71	5	5	1	1	**5**	0.01	0.01	0.2	-4.84	-4.68
3	0.71	5	5	1	1	**5.5**	0.01	0.01	0.2	-3.99	-3.83
3	0.71	5	5	1	1	**6**	0.01	0.01	0.2	-3.15	-2.99
3	0.71	5	5	1	1	1	**9**	0.01	0.2	-11.5	-11.42
3	0.71	5	5	1	1	1	**11**	0.01	0.2	-11.5	-11.42
3	0.71	5	5	1	1	1	**13**	0.01	0.2	-11.5	-11.43
3	0.71	5	5	1	1	1	0.01	**0.06**	0.2	-12.92	-12.76
3	0.71	5	5	1	1	1	0.01	**0.08**	0.2	-12.46	-12.3
3	0.71	5	5	1	1	1	0.01	**0.10**	0.2	-12.06	-11.89
3	0.71	5	5	1	1	1	0.01	0.01	**5**	-11.57	-11.41
3	0.71	5	5	1	1	1	0.01	0.01	**20**	-11.49	-11.33

The effect of different parameters on skin friction, nusselt number and Sherwood number are in the table 1-3 for both at varying wall temperature and constant wall temperature. From table1 represents the skin friction for both the cases that increases in terms of prandtl number, direction of fluid flow, visco-elastic parameter, magnetic field, dufour number and heat generation where it decreases in terms of radiation parameter, thermal and mass Grashof number. In table 2 nusselt number explains about the heat transfer within a fluid. In terms of radiation parameter, thermal heat generation and dufour number increases in the nusselt and the value of prandtl number reacts oppositely. Table 3 represents the Sherwood number that it reacts opposite to the nusselt number. Sherwood number explains the convective mass transfer and diffusive mass transport in the fluid.

Table 2: Nusselt number at variable and constant wall temperature

R	**Pr**	**E**	**Df**	**Nu(A_T=1)**	**Nu(A_T=0)**
1	0.71	0.01	0.2	-0.30	-0.30
5	0.71	0.01	0.2	-0.08	-0.08
10	0.71	0.01	0.2	-0.03	-0.03
15	0.71	0.01	0.2	-0.01	-0.01
1	**0.8**	0.01	0.2	-0.35	-0.34
1	**0.9**	0.01	0.2	-0.38	-0.37
1	**1**	0.01	0.2	-0.43	-0.42
1	0.71	**0.03**	0.2	-0.28	-0.27
1	0.71	**0.05**	0.2	-0.25	-0.24
1	0.71	**0.07**	0.2	-0.20	-0.20
1	0.71	0.01	**0**	-0.30	-0.30
1	0.71	0.01	**10**	-0.30	-0.29
1	0.71	0.01	**20**	-0.30	-0.29

Table 3: Sherwood number at variable and constant wall temperature

R	**Pr**	**H**	**Sh (A_T=1)**	**Sh (A_T=0)**
1	0.71	0.01	-0.26	-0.25
5	0.71	0.01	-0.34	-0.33
10	0.71	0.01	-0.35	-0.34
15	0.71	0.01	-0.35	-0.34
1	**0.8**	0.01	-0.24	-0.23
1	**0.9**	0.01	-0.22	-0.22
1	**1**	0.01	-0.20	-0.20
1	0.71	**0.03**	-0.27	-0.26
1	0.71	**0.05**	-0.29	-0.29
1	0.71	**0.07**	-0.30	-0.29

5. CONCLUSION

In this concept of the effect of an unsteady MHD two dimensional free convection flow of a viscous dissipation, incompressible, radiating, chemically reacting and radiation absorbing Kuvshinski fluid through a porous medium past a semi-infinite vertical plate has been studied. The non-dimensional equations governing the flow are solved by perturbation technique. The fundamental parameters found to have an influence on the problem under consideration are magnetic field parameter, radiation parameter, permeability of the porous medium, radiation absorption parameter, Dufour number, thermal Grashof number, modified Grashof number, Schmidt number, chemical reaction parameter and Prandtl number.

When plate is maintained at variable and constant wall temperature, the main conclusion are as follows

a) The velocity is observed to increases with increasing value of R, Gr, Up, λ, Gc where as it has reverser effect in the case of Pr, Df, K, η and M.
b) Temperature boundary layer increased with increase in R, Df but decrease for increasing values of Pr.
c) Concentration boundary layer increases with increase of Sc and decrease of S_0, Kr.
d) Skin friction increases in terms of increases of Prandtl number, magnetic parameter, direction of fluid flow, magnetic field, heat generation, dufour effect and visco-elastic fluid where as it decrease of radiation parameter, thermal and mass Grashof number.
e) Nusselt number increases with the increase of radiation parameter, Dufour number and thermal heat generation and in terms of prandtl number reacts oppositely.
f) Sherwood number decreases with the increase of radiation parameter and thermal heat generation but in terms of prandtl number it increases.

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