Soret , Dufour and Radiation effects on an unsteady mass transfer flow through a highly porosity bounded by a vertical infinite moving plate in the presence of the heat generation and chemical reaction

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***Abstract**: The Soret and Dufour effects on unsteady mass transfer flow through a highly porosity bounded by a vertical infinite moving plate in the presence of the heat generation and chemical reaction have been studied. The Rosseland approximation has been used to describe the radiative heat flux in energy equation. The governing equations are solved numerically by using Galerkin finite element method. The effects of various parameters on the velocity, temperature and concentration fields have been examined with the help of graphs..*

Keywords *Dufour effect, Soret Effect, MHD, Chemical reaction, Radiation effect, Finite element method..*

I. INTRODUCTION

The study of electrically conducting fluid (MHD) continues to attract the interest of engineering science and applied Mathematics researchers outstanding to extensive applications of such flows in the context of aerodynamics, engineering, geophysics and aeronautics. Soret effect is one of the mechanisms in the transport phenomena in which molecules are transported in multi-component mixture driven by temperature gradient. Convective heat and mass transfer in porous media has also been a subject of concern for the last few decades due to its application in various disciplines, such as geophysical, solar power collectors, cooling of electronic system, chemical catalytic reactors. Alam and Rahman [1] investigated the Dufour and Soret effects on the mixed convection flow past a vertical porous flat plate with variable suction.. A.Nayak et.al [2] discussed Soret and Dufour effects on mixed convection unsteady MHD boundary layer flow over stretching sheet in porous medium with chemically reactive species. M.Nawaz et.al [3] investigated Dufour and Soret effects on MHD flow of Visccous fluid between radially stretching sheets in porous medium.

The Soret and Dufour are found to be useful as the Soret effect is utilized for isotope separation and in a mixure of gases of light and medium molecular weight, the Dufour effect is found to be of considerable order of magnitude such that it cannot be neglected. R.N .Barik [4] studied free convection heat and mass transfer MHD Flow in a vertical channel in the presence of the chemical reaction. Md Enamul *et.al* [5] analyzed Studied Dufour and Soret effect on steady MHD flow in presence of heat generation and magnetic field past in inclined stretching sheet. N.Ahmed et.al [6] studied unsteady MHD free convective flow past a vertical porous plate immersed in a porous medium with hall current, thermal diffusion and heat source. I.J Uwanta and K.K Asogwa [7] investigated MHD fluid flow over a vertical plate with Dufour and Soret effects. N.Pandya and Ravi Kant Yadav [8] examined Soret – Dufour effects on unsteady MHD flow of dusty fluid over inclined porous plate embedded in porous medium. M.Bhavana et.al [9] studied the soret effect on free convective unsteady MHD flow over a vertical plate with heat source. N.Vedavathi et.al [10] examined the radiation and mass transfer effects on unsteady MHD convective flow past an infinite vertical plate with Dufour and Soret effects. Soret and Dufour effects on free convective heat and mass solute transfer in fluid saturated inclined porous cavity was study by Chandra Shekar and Kishan [11].

M. Turkyilmazoglu and Pop [12] analyzed Soret and heat source effects on the unsteady radiative MHD free convection floe from an impulsively starter infinite vertical plate. R.Muthucumaraswamy [13] studied effect of a chemical reaction on a moving isothermal vertical surface with suction. Basant K.Jha et.al [14] examined Dufour and Soret effects on melting from a vertical plate embedded in saturated porous media. R. Muthucumaraswamy, T. Kulandaivel [15] studied Chemical reaction effects on moving infinite vertical plate with uniform heat flux and variable mass diffusion. J.Anand Rao and S.Shivaiah [16] analyzed chemical reaction effects on an unsteady MHD free convective flow past in infinite vertical plate with constant suction and heat source. D.Hunegna and N.Kishan [17] analyzed Unsteady MHD Heat and Mass Transfer Flow over Stretching Sheet in Porous Medium with Variable Properties Considering Viscous Dissipation and Chemical Reaction. P.R Sharmal et.al [18] have investigated unsteady MHD forced convection flow and mass transfer along a vertical stretching sheet with heat source/ sink and variable fluid properties. J.Venkata Madhu et.al [19] Dufour and Soret effect on unsteady MHD free convection flow past a semi – infinite moving vertical plate in a porous medium with viscous dissipation. J.Anand rao et.al [20] discussed finite element analysis of unsteady MHD free convection flow past an infinite vertical plate with Soret, Dufour, Thermal radiation and heat.
The present work aims to study the effects of Soret and Dufour on an unsteady mass transfer flow through a high porosity bounded by a vertical infinite moving plate in the presence of the heat generation and chemical reaction.

II. MATHEMATICAL ANALYSIS

We have consider unsteady MHD two dimensional flow of a laminar, viscous, incompressible fluid through highly porous medium past an infinite vertical moving porous plate in the presence of thermal radiation is considered. The fluid and porous structure are assumed to be in local thermal equilibrium. The axis is chosen along the plate in the direction opposite to the direction of gravity and the - axis is taken normal to the plate. Since the flow field is extreme size, all the variable are functions of and only. Under the usual Boussinesq's approximation and boundary layer approximation, the equations of mass, momentum, energy and diffusion are

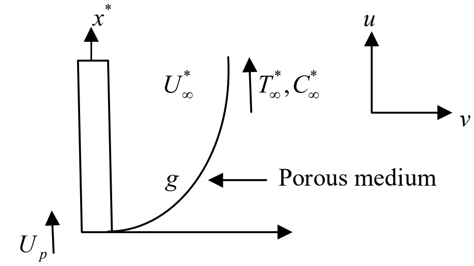

Figure 1. Flow configuration and coordinate system.

Equation of continuity:

$$\frac{\partial v^*}{\partial y^*} = 0 \qquad \text{--- (1)}$$

Momentum equation:

$$\frac{\partial u^*}{\partial t^*} + v^* \frac{\partial u^*}{\partial y^*} = -\frac{1}{\rho}\frac{\partial p^*}{\partial x^*} + \nu \frac{\partial^2 v^*}{\partial y^{*2}} + g\beta(T^* - T^*_\infty) + g\beta^*(C^* - C^*_\infty) - \frac{\nu}{K^*}\varphi u^* \qquad \text{--- (2)}$$

Energy equation:

$$\sigma \frac{\partial T^*}{\partial t^*} + \varphi v^* \frac{\partial T^*}{\partial y^*} = \frac{k}{\rho c_p}\frac{\partial^2 T^*}{\partial y^{*2}} - \frac{\varphi}{\rho c_p}\frac{\partial q_r}{\partial y^*} + \frac{Q}{\rho c_p}(T^* - T^*_\infty) + \frac{D_m K_t}{C_s C_p}\frac{\partial^2 C^*}{\partial y^{*2}} \qquad \text{--- (3)}$$

Diffusion equation:

$$\frac{\partial C^*}{\partial t^*} + v^* \frac{\partial C^*}{\partial y^*} = D\frac{\partial^2 C^*}{\partial y^{*2}} - K_r^*(C^* - C^*_\infty) + \frac{D_m K_t}{T_m}\frac{\partial^2 T^*}{\partial y^{*2}} \qquad \text{--- (4)}$$

Where x^*, y^*, and t^* are the dimensional distances along and perpendicular to the plate and dimensional time, respectively; u^* ,and v^* the components of dimensional velocities along x^* and y^* directions respectively; C^* and T^* the dimensional concentration and temperature of the fluid, ρ the fluid density, ν the kinematic viscosity , c_p the specific heat at constant pressure, σ the heat capacity ratio, g the acceleration due to gravity , β and β^* the volumetric coefficient of thermal and concentration expansion K^* the permeability of the porous medium, φ the porosity, D the molecular diffusivity, K_r^* the chemical reaction parameter, and k the fluid conductivity. The third and fourth term on the right hand side of the momentum equation (2) denote the thermal and concentration buoyancy effects, respectively, and the fifth term represents the bulk matrix linear resistance, that is Darcy term, Also, the second term on right hand side of the energy equation (3) represents thermal radiation. The radiative heat flux term by using the Rosseland approximation is given [21] by

$$q_r = -\frac{4\sigma_s}{3K_e}\frac{\partial T^{*4}}{\partial y^*} \quad \text{-- (5)}$$

Where σ_s is the Stefan – Boltzmann constant and K_e is the mean absorption coefficient. For sufficiently small temperature difference within the flow we can expressed T^{*4} as a linear function of the temperature and expanding

$$T^{*4} \cong 4T_\infty^3 T^* - 3T_\infty^{*4} \quad \text{--- (6)}$$

Under these assumptions, the approximate boundary conditions for the velocity, temperature and concentration fields are

$$\left.\begin{array}{ll} u^* = U_p^*, T^* = T_w^* + \varepsilon(T_w^* - T_\infty^*)e^{n^*t^*}, & \\ C^* = C_w^* + \varepsilon(C_w^* - C_\infty^*)e^{n^*t^*} & at \quad y^* = 0 \\ u^* = U_\infty^*, T^* \to T_\infty^*, C^* \to C_\infty^* & at \quad y^* \to \infty \end{array}\right\} \quad \text{--- (7)}$$

Where U_p^* is the wall dimensional concentration velocity; T_w^* and C_w^* are wall dimensional temperature and concentration, respectively; U_∞^*, T_∞^*, and C_∞^* are the free stream dimensional velocity, temperature and concentration, respectively, n^* is the constant.

It is clear from (1) that the suction velocity normal to the plate is either a constant or a function of time. Hence the suction velocity normal to the plate is taken as

$$v^* = -v_0,\ v_0 > 0 \quad \text{--- (8)}$$

Where $-v_0$ is scale of suction velocity which is a nonzero positive constant. The negative sign indicates that suction is towards the plate.

Outside the boundary layer, (2) gives

$$\frac{1}{\rho}\frac{\partial p^*}{\partial x^*} = -\frac{\varphi \nu}{K^*}U_\infty^* \quad \text{--- (9)}$$

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

$$\left.\begin{array}{l} y = \frac{\nu_0 y^*}{\nu}, u = \frac{u^*}{U_\infty^*}, \nu = \frac{\nu^*}{\nu_0}, U_p = \frac{U_p^*}{U_\infty^*}, \\ t = \frac{\nu_0^2 t^*}{\nu}, \lambda = \frac{\sigma}{\varphi}, \theta = \frac{T^* - T_\infty^*}{T_w^* - T_\infty^*}, Sc = \frac{\nu}{D}, \\ C = \frac{C^* - C_\infty^*}{C_w^* - C_\infty^*}, n = \frac{\nu n^*}{\nu_0^2}, Q = \frac{\nu Q_0}{\rho C_p \nu_0^2}, \\ Gc = \frac{g\beta^*\left(C_w^* - C_\infty^*\right)}{U_\infty^* \nu_0^2}, Gr = \frac{g\beta\left(T_w^* - T_\infty^*\right)}{U_\infty^* \nu_0^2}, \\ K = \frac{K^* \nu_0^2}{\varphi \nu^2}, S_0 = \frac{D_m K_t\left(T_w^* - T_\infty^*\right)}{T_m \nu\left(C_w^* - C_\infty^*\right)}, \\ R = \frac{K_e k}{4\varphi\sigma_s T_\infty^3}, \Pr = \frac{\varphi\nu\rho C_p}{k}, Kr = \frac{K_r^* \nu}{\nu_0^2} \\ Du = \frac{D_m K_t\left(C_w^* - C_\infty^*\right)}{C_s C_p \nu\left(T_w^* - T_\infty^*\right)}, Ec = \frac{\nu_0^2}{c_P\left(T_w^* - T_\infty^*\right)} \end{array}\right\} \quad \text{--- (10)}$$

In view of (5) - (10), (2) - (4) reduce to the following non dimensional form:

$$\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + Gr\theta + GcC + \frac{1}{K}(1-u) \quad \text{--- (11)}$$

$$\lambda\frac{\partial \theta}{\partial t} - \frac{\partial \theta}{\partial y} = \frac{1}{\Gamma}\frac{\partial^2 \theta}{\partial y^2} + Q\theta + Ec\left(\frac{\partial u}{\partial y}\right)^2 + Du\left(\frac{\partial^2 C}{\partial y^2}\right) \quad \text{--- (12)}$$

$$\frac{\partial C}{\partial t} - \frac{\partial C}{\partial y} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} - KrC + S_0\left(\frac{\partial^2 \theta}{\partial y^2}\right) \quad \text{--- (13)}$$

Where $\Gamma = (1 - 4/(3R+4))\Pr = \frac{1}{d}$ and $Gr, Gc, \Pr, Sc, Kr, R, Q, Ec, Du, S_0$,and K are the thermal Grashof number, Solutal Grashof number, Prandtl number, Schmidt number, chemical reaction parameter ,radiation parameter, heat generation parameter, Ekert number, Dufour number, Soret number and permeability of the porous medium respectively.

$$\left.\begin{array}{ll} u = U_p, \theta = 1 + \varepsilon e^{nt}, C = 1 + \varepsilon e^{nt} & at \quad y = 0 \\ u \to 1, \quad \theta \to 0, \quad C \to 0 & as \quad y \to \infty \end{array}\right\} \quad \text{-- (14)}$$

III. Solution of the problem

Equations (11)-(13) are coupled, nonlinear partial differential equation and these cannot be solved in closed form. By applying the Galerkin element method for equation (11) over the two nodded linear element (e), $(y_j \le y \le y_k)$ is

$$\int_{y_j}^{y_k} \left\{ \psi^{(e)T} \left[\frac{\partial^2 u^{(e)}}{\partial y^2} + \frac{\partial u^{(e)}}{\partial y} - \frac{\partial u^{(e)}}{\partial t} - N u^{(e)} + R_1 \right] \right\} dy = 0 \quad \text{--- (15)}$$

Here $R_1 = Gr\theta + GcC + N, N = \frac{1}{K}$

Integrating the first term in equation (15) by parts one obtains

$$\left\{ \psi^{(e)T} \frac{\partial u^{(e)}}{\partial y} \right\}_{y_j}^{y_k} - \int_{y_j}^{y_k} \frac{\partial \psi^{(e)T}}{\partial y} \frac{\partial u^{(e)}}{\partial y} dy - \int_{y_j}^{y_k} \psi^{(e)T} \frac{\partial u^{(e)}}{\partial t} dy - N \int_{y_j}^{y_k} u^{(e)} dy + \int_{y_j}^{y_k} \psi^{(e)T} R_1 dy = 0 \quad \text{--- (16)}$$

Since the derivative $\frac{\partial u}{\partial y}$ is not specified at either ends of the element (e), $(y_j \le y \le y_k)$, so that neglecting the first term in equation (16) we get

$$\int_{y_j}^{y_k} \frac{\partial \psi^{(e)T}}{\partial y} \frac{\partial u^{(e)}}{\partial y} dy + \int_{y_j}^{y_k} \psi^{(e)T} \frac{\partial u^{(e)}}{\partial t} dy + N \int_{y_j}^{y_k} u^{(e)} dy - \int_{y_j}^{y_k} \psi^{(e)T} R_1 dy = 0 \quad \text{--- (17)}$$

Finite element model may be obtained from equation (17) by substituting finite element approximation over the two nodded linear element (e), $(y_j \le y \le y_k)$ of the form:

$u^{(e)} = N^{(e)} \psi^{(e)}$ Here $\psi^{(e)} = \begin{bmatrix} \psi_j & \psi_k \end{bmatrix}$, $\phi^{(e)} = \begin{bmatrix} u_j & u_k \end{bmatrix}^T$.Where u_j, u_k are the velocity components at j^{th} and k^{th} nodes of the typical element (e), ($y_j \le y \le y_k$) and ψ_j, ψ_k are the basis functions defined as follows.

$\psi_j = \frac{y_k - y}{y_k - y_j}, \psi_k = \frac{y - y_j}{y_k - y_j}$ Substituting equation (18) into (17), the following is obtained:

$$\frac{1}{l^{(e)}} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} u_j \\ u_k \end{bmatrix} + \frac{l^{(e)}}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} \dot{u}_j \\ \dot{u}_k \end{bmatrix} - \frac{1}{2} \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} u_j \\ u_k \end{bmatrix} + \frac{N l^{(e)}}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} u_j \\ u_k \end{bmatrix} = \frac{R_1 l^{(e)}}{2} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

where '•' denote the differentiation with respect to time, $l^{(e)} = y_k - y_j$ is the length of the element. Assembling the element equations by inter-element connectivity for two consecutive elements $y_{i-1} \le y \le y_i$ and $y_i \le y \le y_{i+1}$.

$$\frac{1}{l^{(e)^2}} \begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} + \frac{1}{2l^{(e)}} \begin{bmatrix} -1 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} + \frac{1}{6} \begin{bmatrix} 2 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix} \begin{bmatrix} \dot{u}_{i-1} \\ \dot{u}_i \\ \dot{u}_{i+1} \end{bmatrix} + \frac{N}{6} \begin{bmatrix} 2 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix} \begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} = \frac{R_1}{2} \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}$$

Now put row corresponding to the node i to zero, the following difference schemes with $l^{(e)} = h$ is obtained:

$$\frac{1}{h^2}\left[-u_{i-1} + 2u_i - u_{i+1}\right] + \frac{1}{2h}\left[-u_{i-1} + u_{i+1}\right] + \frac{1}{6}\left[\dot{u}_{i-1} + 4\dot{u}_i + \dot{u}_{i+1}\right] + \frac{N}{6}\left[u_{i-1} + 4u_i + u_{i+1}\right] = R_1 \quad \text{--- (18)}$$

Applying the trapezoidal rule, from the equation (18), following system of equations in Crank – Nicholson method are obtained:

$$(2 - 6r + 3rh + Nk) u_{i-1}^{j+1} + (8 + 12r + 4Nk) u_i^{j+1} + (2 - 6r - 3rh + Nk) u_{i+1}^{j+1} = (2 + 6r - 3rh - Nk) u_{i-1}^{j} + (8 - 12r - 4kN) u_i^{j} + (2 + 6r + 3rh - Nk) u_{i+1}^{j} + 12R_1 k$$

$$A_1 u_{i-1}^{n+1} + A_2 u_i^{n+1} + A_3 u_{i+1}^{n+1} = A_4 u_{i-1}^{n} + A_5 u_i^{n} + A_6 u_{i+1}^{n} + R^* \quad \text{--- (19)}$$

$A_1 = 2 - 6r + 3rh + Nk$
$A_2 = 8 + 12r + 4Nk,$
$A_3 = 2 - 6r - 3rh + Nk$
Where $A_4 = 2 + 6r - 3rh - Nk$
$A_5 = 8 - 12r - 4Nk$
$A_6 = 2 + 6r + 3rh - Nk$
$R^* = 12R_1 k = 12k((Gr)\theta_i^j + (Gm)C_i^j)$

Similarly applying the Galerkin finite element method for equation (12) - (13) the following equations are obtained:

$$B_1\theta_{i-1}^{j+1} + B_2\theta_i^{j+1} + B_3\theta_{i+1}^{j+1} = B_4\theta_{i-1}^j + B_5\theta_i^j + B_6\theta_{i+1}^j + R^{**} \quad \text{--- (20)}$$

$$C_1C_{i-1}^{j+1} + C_2C_i^{j+1} + C_3C_{i+1}^{j+1} = C_4C_{i-1}^j + C_5C_i^j + C_6C_{i+1}^j + R^{***} \quad \text{--- (21)}$$

Where
$B_1 = 2\lambda - 6rd + 3rh + kQ$
$B_2 = 8\lambda + 12rd - 4k_1Q$
$B_3 = 2\lambda - 6rd - 3rh - kQ$
$B_4 = 2\lambda + 6rd - 3rh + kQ$
$B_5 = 8\lambda - 12rd + 4k_1Q$
$B_6 = 2\lambda + 6rd + 3rh + kQ$
$C_1 = 2Sc - 6r + 3rh.Sc + kScKr$
$C_2 = 8Sc + 12r + 4kScKr$
$C_3 = 2Sc - 6r - 3rh.Sc + kScKr$
$C_4 = 2Sc + 6r - 3rhSc - kScKr$
$C_5 = 8Sc - 12r - 4kScKr$
$C_6 = 2Sc + 6r + 3rh.Sc - kScKr$

$$R^{**} = 12kDu\left(\frac{\partial^2 C_i}{\partial y_i^2}\right), R^{***} = 12kS_0\left(\frac{\partial^2 \theta_i}{\partial y_i^2}\right)$$

Here $r = \frac{k}{h^2}$ and h, k are mesh sizes along y - direction and t – direction respectively. Index i, j refers to the space and time. In the equations (19), (20) and (21) taking $i = 1(1)n$ using initial and boundary conditions (14), the following system of equations are obtained:

$$A_iX_i = B_i, \qquad i = 1(1)3 \quad \text{--- (22)}$$

Where A_i's are matrices of order n and X_i, B_i's column matrices having n - components. The solutions of above system of equations are obtained by Thomas algorithm for velocity, temperature, concentration. For various parameters the results are computed and presented graphically.

IV. Results and Discussion

Numerical calculations have been carried out for different values of $Gr, Gc, \Pr\ Sc, Kr, R$ Q, Ec , Du , S_0 , K and depicted graphically. Figure.2 shows that the velocity profiles increases with an increases of Grashof number *i.e* the thermal Grashof number signifies the relative effect of the thermal buoyancy force to the viscous hydrodynamic force in the boundary layer. From Figure.3 it can be seen that, the velocity increases with increasing values of the Solutal Grashof number (Gc), it defines the ratio of the species buoyancy force to the viscous hydrodynamic force.

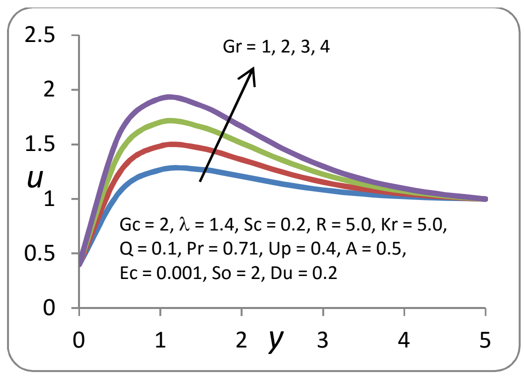

Fig.2.Velocity profile for different Gr Values

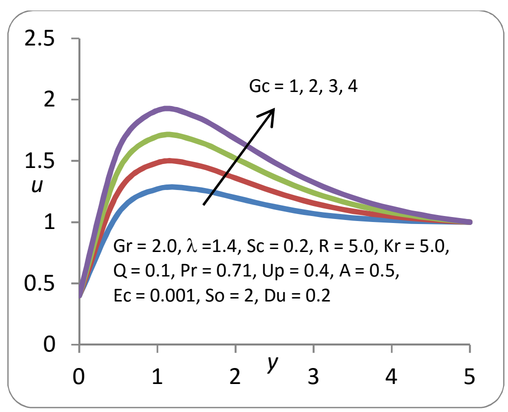

Fig.3.Velocity profiles for different Gc values

Figure.4 exhibits the variations of the velocity profile for different values of permeability of the porous medium K. Clearly as K increases the velocity tends to increase. The Figure.5 and Figure.6 illustrate the velocity and temperature profiles for different values of radiation parameter R. the radiation parameter R defines the relative contribution of conduction heat transfer to thermal radiation. As the radiation parameter increases the result in a decrease in the velocity and temperature within the boundary layer, as well as decreased thickness of the velocity and temperature boundary layer.

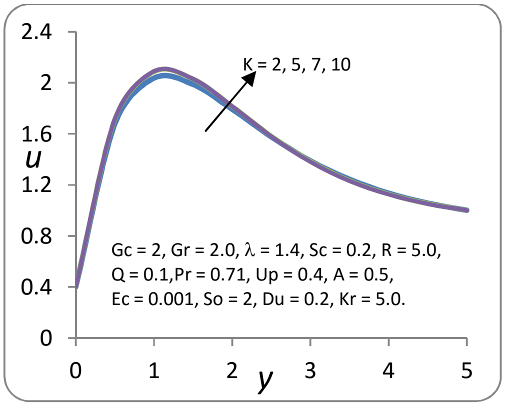

Fig.4. Velocity profile for different K values

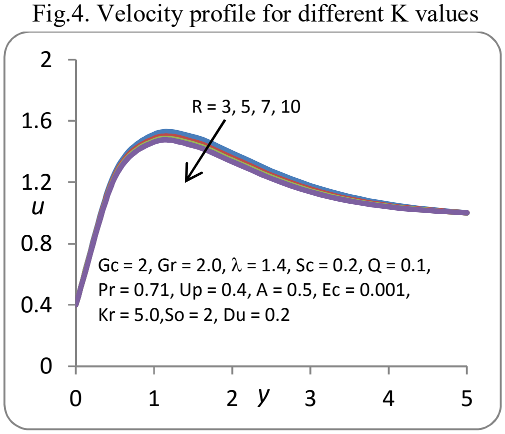

Fig.5.Velocity profiles for different R values

For different values of the Prandtl number Pr the velocity and temperature profiles are plotted in Figure.7 and 8. The numerical result shows that the effect of increasing Pr values results in a decreasing velocity as wells as temperature. The reason is that smaller values of Prandtl number are equivalent to increase in thermal conductivity of the fluid, and therefore heat is able to diffuse Pr. Hence in the case of smaller Pr numbers the thermal boundary layer is thicker and the rate of heat transfer is reduced.

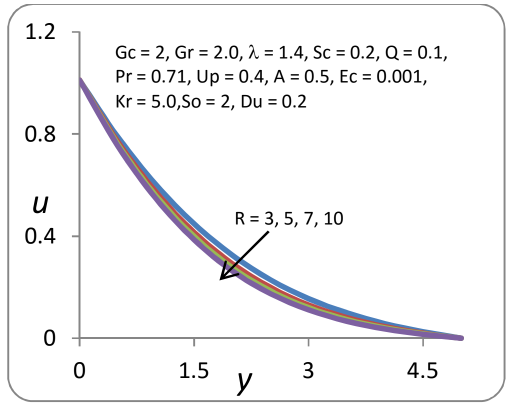

Fig.6.Temperature profile for different R values

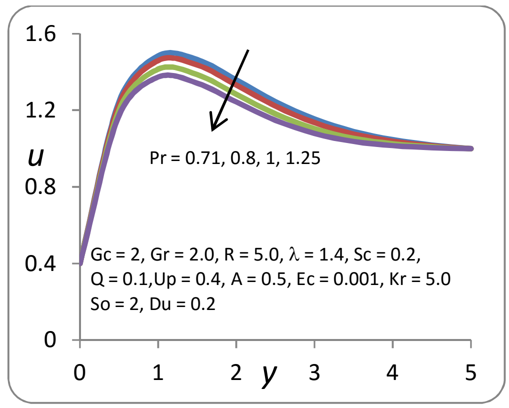

Fig.7.Velocity profiles for different Pr values

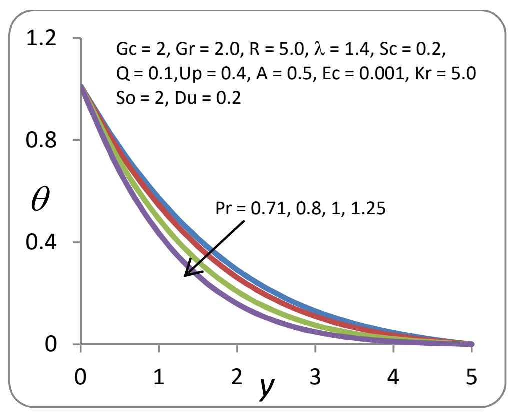

Fig.8.Temperature profile for different Pr values

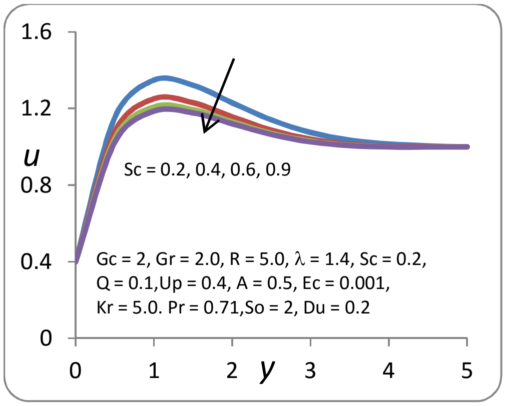

Fig.9.Velocity profiles for different Sc values

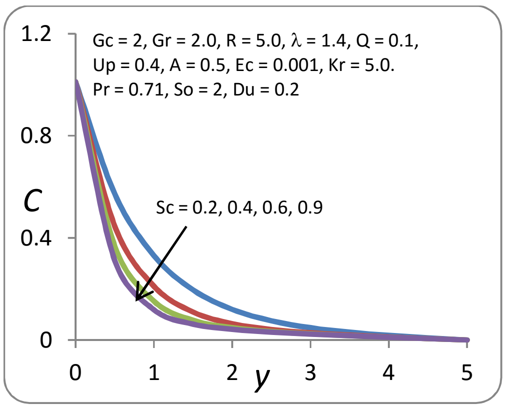

Fig.10. Concentration profile for different Sc values

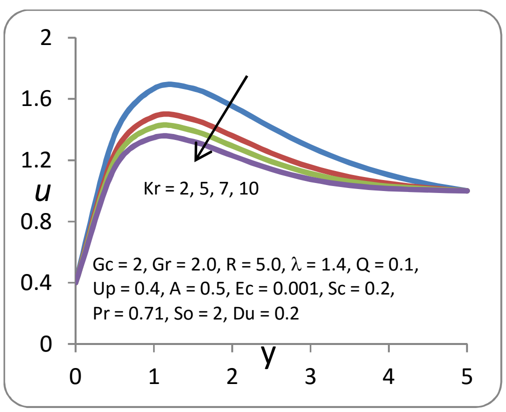

Fig.11. Velocity profiles for different Kr values

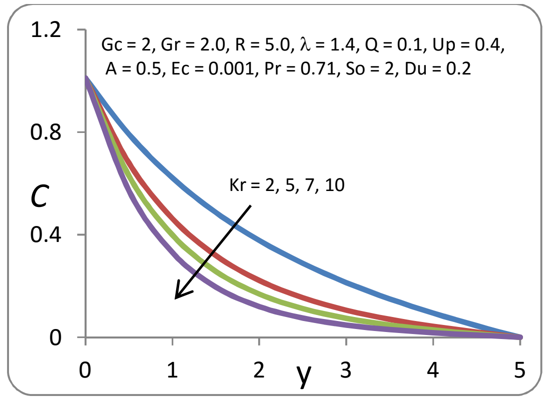

Fig.12. Concentration profile for different Kr values

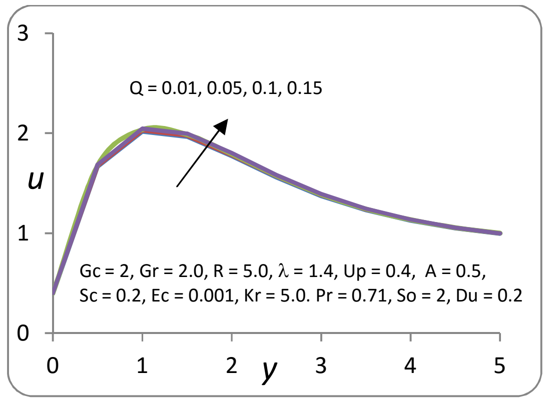

Fig.13. Velocity profiles for different Q values

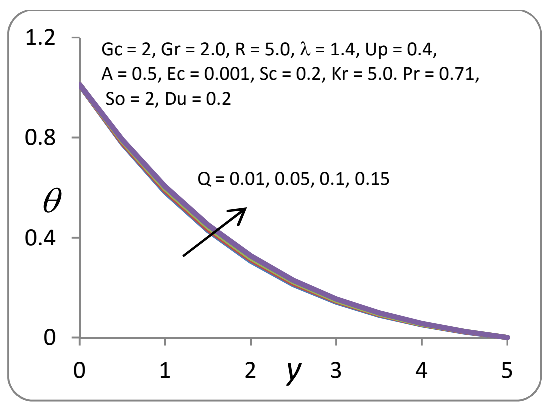

Fig.14.Velocity profiles for different Q values

The effect of Schmidt number Sc on velocity and concentration profiles as shown in Figure.9. and10. As Schmidt number Sc increases the concentration decreases. This causes the concentration buoyancy effects to decrease yielding a reduction in the fluid velocity. The reductions in the velocity and concentration profiles are accompanied by simultaneous reductions in the velocity and concentration boundary layers.

Figure.11 and 12 depicts the effect of chemical reaction parameter Kr on the velocity and concentration. It is notice that the velocity as well as concentration throughout the boundary layer decreases with an increase in Kr. Figure 13 and 14 shows the effect of heat generation parameter Q on the velocity and temperature. It shows that the velocity as well as temperature across the boundary layer increases with an increase in the heat generation parameter Q. Figure 15 and 16 display the velocity and concentration profiles for different values of the Soret number it can be seen that an increase in Soret number results in an increase in the velocity and concentration within the boundary layer. This is because of the mass flux created by temperature gradient is inversely proportional to the mean temperature., this causes the concentration of the fluid increases due to the thermal diffusion rate is increasing with the velocity.

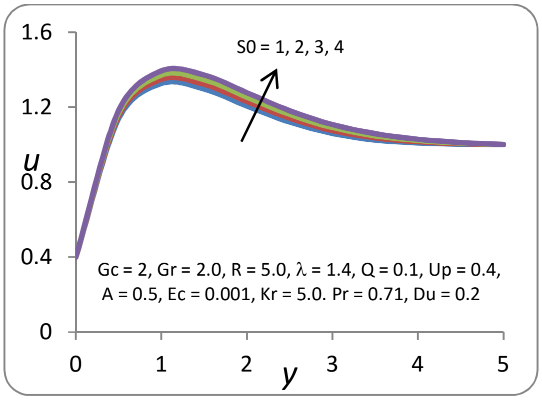

Fig.15.velocity profiles for different So values

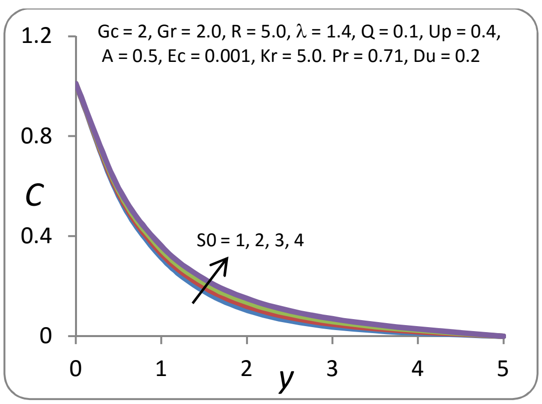

Fig.16. Concentration profile for different So values

For different values of Dufour number, the velocity and temperature profiles are depicted in Figure 17 and 18. It is notice that an increase in Dufour number results in an increase in the velocity and temperature through the boundary layer. This due to the fact the energy flux created by the concentration gradient is inversely proportional to the velocity.

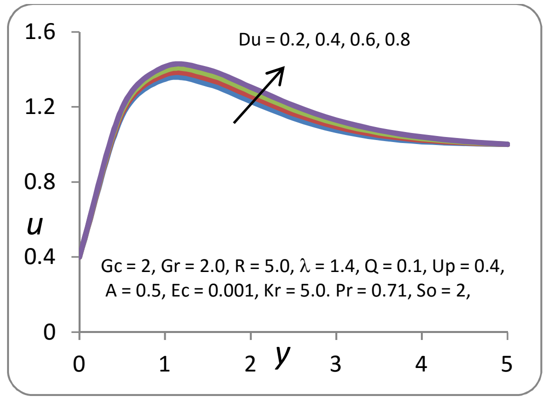

Fig.17.velocity profiles for different Du values

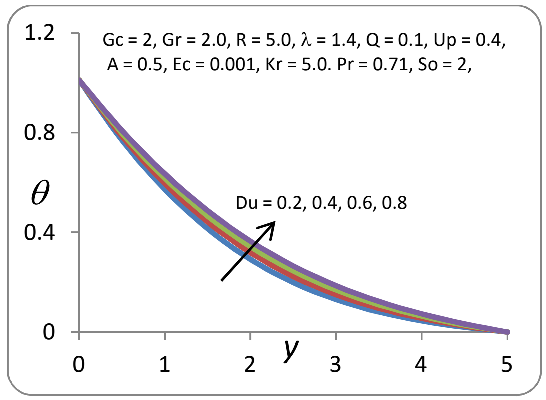

Fig.18.Temperature profiles for different Du values

V. Conclusions

In the present study, we have investigated the Soret and Dufour effects on unsteady mass transfer flow through a highly porosity bounded by a vertical infinite moving plate in the presence of the heat generation and chemical reaction. Numerical calculations are carried out for various values of the dimensionless parameter. The main results of the present study can be listed below.

- The velocity profile increases with increase in thermal Grashof number(Gr), Solutal Grashof number(Gc), Prandtl number(Pr), radiation parameter(R), heat generation parameter(Q), Dufour number(Du) and permeability of the porous medium(K)
- The temperature distribution decreases with increase in the values of Prandtl number (Pr), radiation parameter(R).
- Increasing the values of heat generation parameter (Q) and Dufour number (Du) there is an increase in the temperature profile.

- Velocity and concentration decreases with an increase Schmidt number (Sc) and chemical reaction parameter (Kr).
- An increase in the Soret number (So) leads to an increase in velocity and concentration.

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