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Soret and Dufour Effects on Steady MHD Flow in Presence of Heat Source through a Porous Medium over a Non-Isothermal Stretching Sheet

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Abstract: *Heat and mass transfer characteristics of MHD forced convection flow over a non-isothermal stretching sheet embedded in a porous medium subjected to a heat source is investigated numerically by taking into account the Soret and Dufour effects. The velocity, temperature and concentration profiles are drawn for various values of permeability parameter, heat source parameter, magnetic field parameter, Soret and Dufour numbers, thermal stratification parameter. Numerical results of rate of flow, heat and mass transfer for different parameters are presented in tabular form and the results are depicted graphically.*

Keywords: *Chemical reaction, heat and mass transfer, heat source, magnetic field, Soret and Dufour effects, thermal stratification.*

I. Introduction

Convective flow through porous media has attracted considerable attention in last several decades due to its many important engineering, environmental and geophysical applications. The combined heat and mass transfer problems with chemical reactions are investigated by many researchers in recent years. Seddeek and Almushigeh [1] investigated the effects of radiation and variable viscosity on MHD free convective flow and mass transfer over a stretching sheet with chemicalreaction. Kandasamy et al. [2] presented group analysis for Soret and Dufour effects on free convective heat and mass transfer with thermophoresis and chemical reaction over a porous stretching surface in the presence of heat source/sink. Pal and Talukdar [3] presented the combined effects of Joule heating and chemical reaction on unsteady magnetohydrodynamic mixed convection with viscous dissipation over a vertical plate in the presence of porous media and thermal radiation. Joneidi et al. [4] presented analytical treatment of MHD free convection flow over a stretching sheet with chemical reaction. Anjalidevi and Kandasamy [5] studied effects of chemical reaction, heat and mass transfer on laminar flow along a semi-infinite horizontal plate. Seddeek [6] took into account the homogenous chemical reaction of first-order in boundary layer hydromagnetic flow with heat and mass transfer over a heat surface. Various other effects have been included in his analysis such as thermopheresis, variable viscosity and heat generation absorption. Abel et.al. [7] studied the two-dimensional boundary layer problemon mixed convection of an incompressible viscoelastic fluid immersed in porous medium over a stretching sheet. Vyas and Srivastava [8] investigated the radiation effect on MHD flow over a nonisothermal stretching sheet in a porous medium. Vajravelu and Hadjinicolaou [9] studied the convective heat transfer in an electrically conducting fluid at a stretching surface with uniform free stream. Ibrahim and Reddy [10] analysed the similarity solution of heat and mass transfer for natural convection over a moving vertical plate with internal heat generation and a convective boundary condition in the presence of thermal radiation, viscous dissipation and chemical reaction. Shateyi and Motsa [11] studied the thermal radiation effects on heat and mass transfer over an unsteady stretching surface. Cortell [12] studied the effects of viscous dissipation and radiation on the thermal boundary layer over a nonlinearly stretching sheet. Effects of chemical reaction and thermal stratification on MHD free convective heat and mass transfer over a vertical stretching surface embedded in a porous media considering Soret and Dufour numbers provided by Mansour et al.[13]. Mansour and Chamkha [14] studied the effects of Soret and Dufour numbers on free convection over isothermal and adiabetic stretching surfaces embedded in porous media. Sharma and Aich [15] studied the Influence of Chemical Reaction, Magnetic field and Radiation on Heat and Mass Transfer by Free Convection Flow near the Lower Stagnation Point of an Isothermal Horizontal Circular Cylinder in a Porous Medium considering Soret and Dufour Effects, Sharma and Borgohain [16] analyzed the Influence of chemical reaction, Soret and Dufour effects on heat and mass transfer of a binary fluid mixture in porous medium over a rotating disk. Soret and Dufour effects on MHD slip flow with thermal radiation over a porous rotating infinite disk given by Anjali Devi and Uma Devi [17]. Postelnicu [18] has analyzed the effect of chemical reaction on heat and mass transfer by natural convection from vertical surfaces in porous media considering Soret and Dufour Effects neglecting the effect of magnetic field. Sharma [19] has analyzed the Soret and Dufour effects on separation of a binary fluid mixture in MHD natural convection in porous media neglecting the effect of chemical reaction term. Effects of Chemical Reaction on Dissipative Radiative MHD Flow through a Porous Medium over a Nonisothermal Stretching Sheet was studied by Ibrahim [20] neglecting the soret and dufour effects.

The objective of this paper is to study the effects of heat source, Soret and Dufour effects on MHD boundary layer flow over a nonisothermal stretching sheet embedded in porous medium.

II. Mathematical Formulation

We consider steady, laminar, two dimensional MHD forced convective flow together with heat and mass transfer of a viscous incompressible electrically conducting fluid along a stretching sheet placed at the bottom of fluid saturated porous medium. The effects of thermal-diffusion, diffusion-thermal, heat source, a first order homogenous chemical reaction, radiation , viscous dissipation and uniform magnetic field on flow, heat and mass transfer are taken into account. The x-axis is along the sheet and y-axis is perpendicular to it as shown in the figure 1. Two equal and opposite forces are applied along the sheet so that the wall is stretched, keeping the position of the origin unaltered. The stretching velocity varies linearly with the distance from the origin. A uniform magnetic field of strength B_o is applied normal to the sheet. The ambient temperature and concentration far away from the surface of the sheet which is assumed to be uniform is T_∞ and C_∞ where $T_w > T_\infty$ and $C_w > C_\infty$.

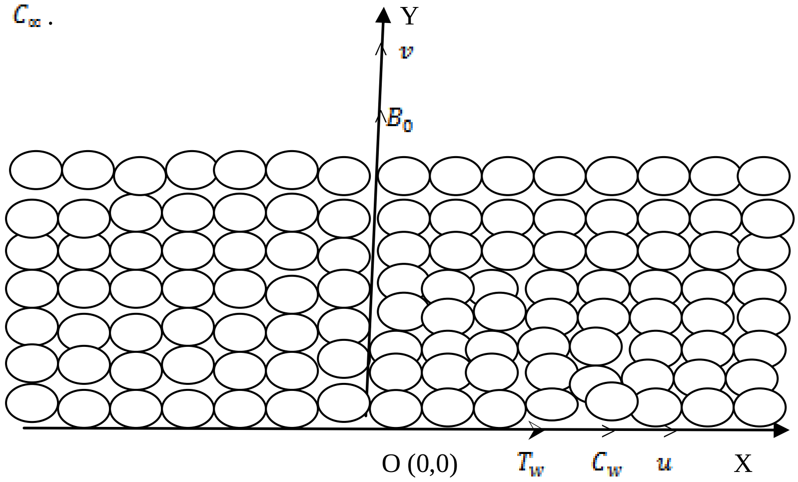


Fig. 1: Physical model and coordinate system

Further it is assumed that both the fluid and the porous medium are in local thermal equilibrium. The fluid is considered to be gray absorbing-emitting radiations but non scattering medium and the Rosseland approximation is used to describe the radiative heat flux in y-direction. Under the Boussinesq approximation, the governing equations are given by

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \qquad \ldots(1)$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} + g\beta(T - T_\infty) + g\beta^*(C - C_\infty) - \frac{\sigma B_0^2 u}{\rho} - \frac{\nu u}{k'} \qquad \ldots(2)$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2} - \frac{1}{\rho C_p}\frac{\partial q_r}{\partial y} + \frac{\mu}{\rho C_p}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{Q_0}{\rho C_p}(T - T_\infty) + \frac{D\,k_T}{C_s C_p}\frac{\partial^2 C}{\partial y^2} \qquad \ldots(3)$$

and $$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D\frac{\partial^2 C}{\partial y^2} + \frac{D k_T}{T_m}\frac{\partial^2 T}{\partial y^2} - K_1(C - C_\infty) \qquad \ldots(4)$$

where u and v are fluid velocity components in the x and y directions respectively, g is acceleration due to gravity, C and T denotes the concentration and temperature of the fluid, ρ is the density of the fluid, β is the coefficient of thermal expansion, β^* is coefficient of concentration expansion, k' is the permeability of porous medium , σ is the fluid electrical conductivity, k and C_p are the thermal conductivity and specific heat of the fluid, C_s is the concentration susceptibility, q_r is the radiative heat flux , D is mass diffusivity, k_T is thermal diffusion ratio, T_m is mean fluid temperature, K_1 is dimensional of chemical reaction.

The radiative heat flux q_r under Rosseland approximation is given by the expression

$$q_r = -\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \qquad \ldots(5)$$

where σ^* is Stefan-Boltzmann constant and k^* is the mean absorption coefficient.

It is assumed that temperature differences within the flow are sufficiently small such that T^4 can be expanded in a Taylor's series about T_∞ and after rejecting higher order terms, we have

$$T^4 = 4T_\infty^3 T - 3T_\infty^4 \qquad \ldots(6)$$

The initial and boundary conditions are

$$\left.\begin{array}{ll} u = cx, v = 0, T = T_w, C = C_w & \dots \text{at } y = 0 \\ u \to 0, T \to T_\infty, C \to C_\infty & \dots \text{as } y \to \infty \end{array}\right\} \quad \dots(7)$$

The similarity transformation is given by

$$\psi = \sqrt{cv}\,xf(\eta), \quad \eta = \sqrt{\frac{c}{v}}\,y, \quad \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty}, \ \emptyset(\eta) = \frac{C - C_\infty}{C_w - C_\infty}, \ T_w - T_\infty = dx^{\alpha}, \ C_w - C_\infty = d_1 x^{\delta} \quad \dots(8)$$

where α is a constant called the thermal stratification parameter, δ is a constant called the wall concentration exponent, c, d and d_1 are all constant.

The stream function is introduced by the equations

$$u = \frac{\partial\psi}{\partial y}, v = -\frac{\partial\psi}{\partial x}. \quad \dots(9)$$

If we introduce the relations (8) into the equations (2), (3)and(4), then we have

$$f''' + ff'' - (f')^2 + Gr\theta + Gc\emptyset - (M + K)f' = 0 \quad \dots(10)$$

$$\theta'' + \frac{3PrR}{3R+4}\left(f\theta' - \alpha f'\theta + Ecf''^2 + Q\theta + D_f\emptyset''\right) = 0 \quad \dots(11)$$

$$\emptyset'' + Sc\left(f\emptyset' - \delta f'\emptyset + S_r\theta'' - \gamma\emptyset\right) = 0 \quad \dots(12)$$

where $M = \frac{\sigma B_0^2}{\rho c}$ is the magnetic field parameter , $Gr = \frac{g\beta(T_w - T_\infty)}{xc^2}$ is the Grashoff number, $Gc = \frac{g\beta^*(C_w - C_\infty)}{xc^2}$ is the modified Grashoff number, $K = \frac{v}{k'c}$ is the permeability parameter, $Pr = \frac{\rho v C_P}{k}$ is the Prandtl number, $Q = \frac{Q_0}{c\rho C_P}$ is the heat generation or absorption parameter, $R = \frac{k^* k}{4\sigma^* T_\infty^3}$ is the radiation parameter, $Ec = \frac{c^2 x^2}{C_P(T_w - T_\infty)}$ is the Eckert number, $D_f = \frac{Dk_T(C_w - c_\infty)}{C_s C_P v(T_w - T_\infty)}$ is the Dufour number, $Sc = \frac{v}{D}$ is the Schmidt number, $S_r = \frac{Dk_T(T_w - T_\infty)}{T_m v(C_w - C_\infty)}$ is the Soret number and $\gamma = \frac{K_1}{c}$ is the chemical reaction parameter.

The initial and boundary conditions (7) becomes

$$\left.\begin{array}{ll} f' = 1, \ f = 0, \ \theta = 1, \emptyset = 1 & \dots \text{at } \eta = 0 \\ f' \to 0, \theta \to 0, \emptyset \to 0 & \dots \text{as } \eta \to \infty \end{array}\right\} \quad \dots(13)$$

III. Results and Discussions

The ordinary differential equations (10), (11) and (12) with the corresponding boundary conditions (13) have been solved numerically by using bvp4c solver of MATLAB. From the process of numerical computation, the local skin friction, the local Nusselt number and the local Sherwood number which are proportional to $-f''(0)$, $-\theta'(0)$ and $-\emptyset'(0)$ respectively are worked out and their numerical values are presented in tabular form. Numerical calculations for f'', θ' and $\emptyset'$ have been carried out by taking various values of parameters K, M, Q, D_f, S_r and α by considering $Gr = 2.0, Gc = 2.0, Pr = 0.71, R = 1.0, \delta = 0.1, Ec = 0.5, Sc = 0.6, \gamma = 0.5$.

Several Cases considered are:

Case I:- $M = 1.0, Q = 0.5, D_f = 0.5, S_r = 0.5, \alpha = 1.0$ with $K = (0.5, 1.0, 1.5)$.

Case II:- $K = 0.5, Q = 0.5, D_f = 0.5, S_r = 0.5, \alpha = 1.0$ with $M = (0.5, 1.0, 1.5)$.

Case III:- $M = 1.0, K = 0.5, D_f = 0.5, S_r = 0.5, \alpha = 1.0$ with $Q = (0.5, 0.8, 1.0)$.

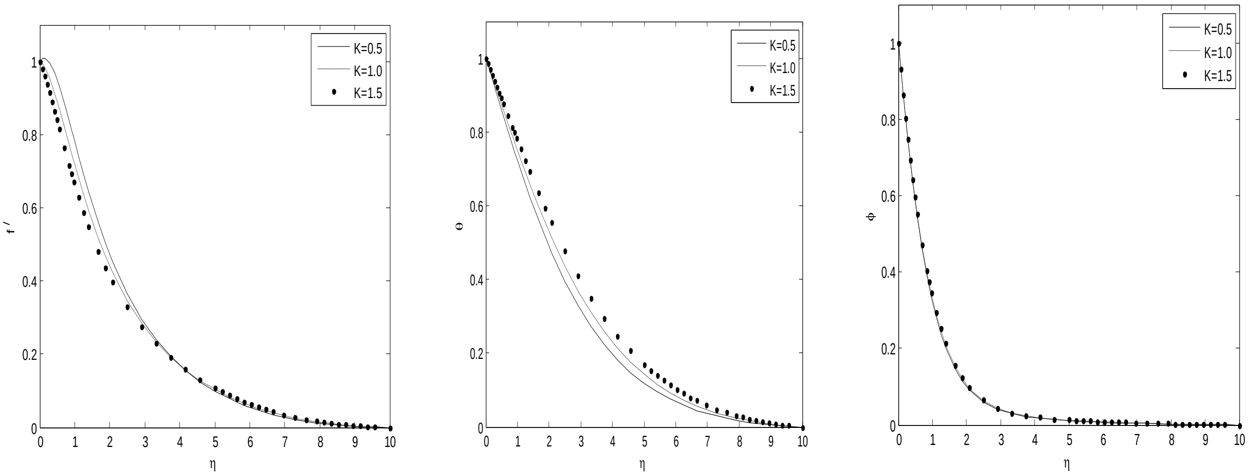
Case IV:- $M = 1.0, K = 0.5, Q = 0.5, S_r = 0.5, \alpha = 1.0$ with $D_f = (0.5, 1.0, 1.5)$.

Case V:- $M = 1.0, K = 0.5, Q = 0.5, D_f = 0.5, \alpha = 1.0$ with $S_r = (0.5, 1.0, 1.5)$.

Case VI:- $M = 1.0, K = 0.5, Q = 0.5, D_f = 0.5, S_r = 0.5$ with $\alpha = (1.0, 2.0, 3.0)$.

The effects of radiation and chemical reaction have already been discussed by [20]. So to save the space, we have avoided the repetition of graph.

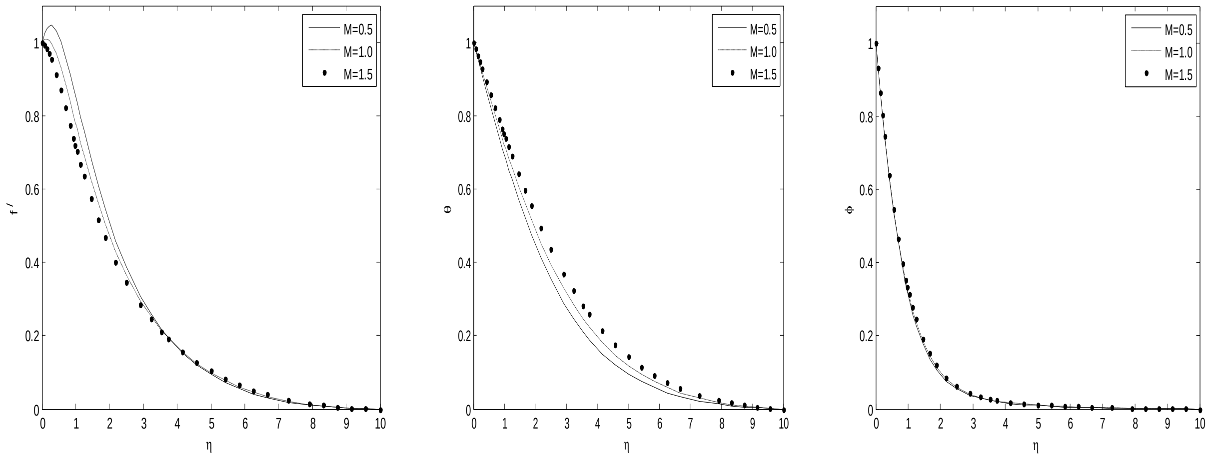
Case 1: Fig. 2(a)-(c) exhibit velocity, temperature and concentration profile for various values of permeability parameter K . It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 2(a) exhibits that with the increase in the values of K, velocity of the fluid decreases in the boundary layer region $0 < \eta < 4$ and reverse effect is observed from $\eta = 4$ onwards. Fig. 2(b) exhibits that with the increase in the value of K, temperature of the fluid increases in the boundary layer region $0 < \eta < 10$. Fig. 2(c) exhibits that with the increase in the value of K, concentration of the fluid slightly increases in the boundary layer region $0 < \eta < 3$ but no effect is observed from $\eta = 3$ onwards.



(a) **(b)** **(c)**

Fig 2: Effect of Permeability parameter K on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

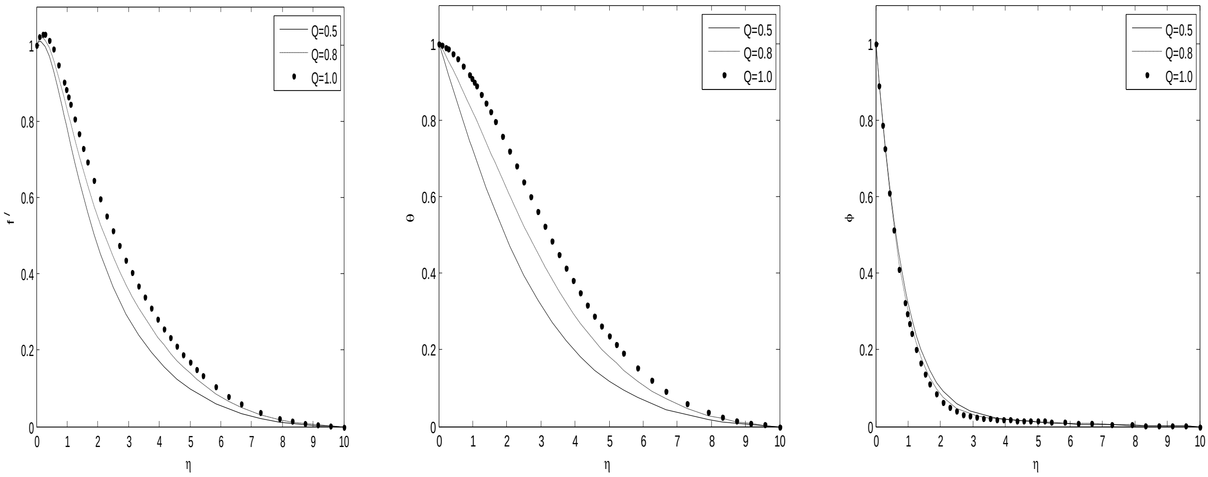
Case 2: Fig. 3(a)-(c) exhibit velocity, temperature and concentration profile for various values of magnetic field parameter M . It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 3(a) exhibits that with the increase in the values of M, velocity of the fluid decreases in the boundary layer region $0 < \eta < 4$ and reverse effect is observed from $\eta = 4$ onwards. Fig. 3(b) exhibits that with the increase in the value of M, temperature of the fluid increases in the boundary layer region $0 < \eta < 10$. Fig. 3(c) exhibits that with the increase in the value of M, concentration of the fluid slightly increases in the boundary layer region $0 < \eta < 5$ but no effect is observed from $\eta = 5$ onwards.



(a) **(b)** **(c)**

Fig 3: Effect of Magnetic field parameter M on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

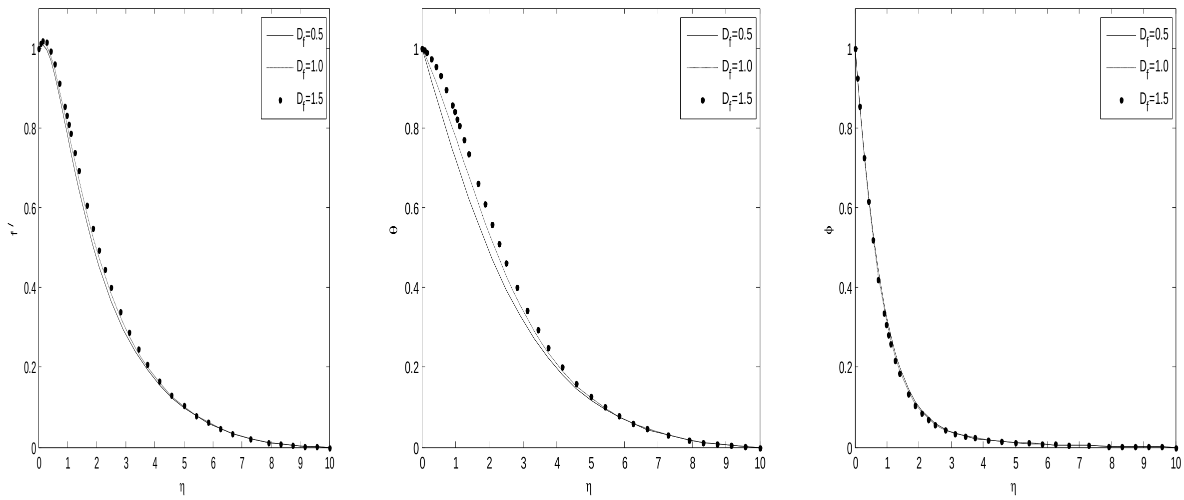
Case 3: Fig. 4(a)-(c) exhibit velocity, temperature and concentration profile for various values of heat source parameter Q . It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 4(a) exhibits that with the increase in the values of Q, velocity of the fluid increases in the boundary layer region $0 < \eta < 10$. Fig. 4(b) exhibits that with the increase in the value of Q, temperature of the fluid increases in the boundary layer region 0 < η< 10. Fig. 4(c) exhibits that with the increase in the value of Q, concentration of the fluid slightly decreases in the boundary layer region 0 < η< 4 but no effect is observedfrom $\eta = 4$ onwards.



(a) **(b)** **(c)**

Fig 4: Effect of heat source parameter Q on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

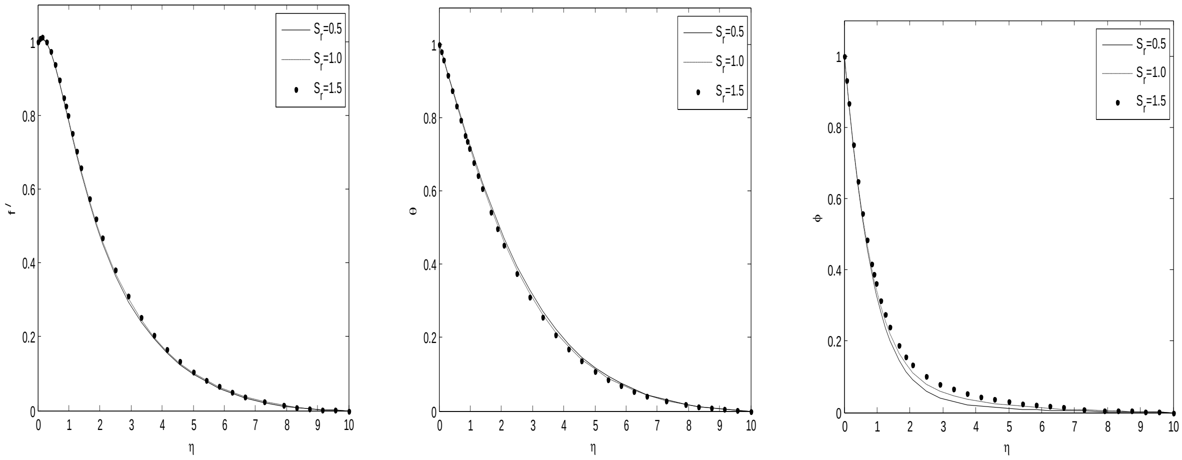
Case 4: Fig. 5(a)-(c) exhibit velocity, temperature and concentration profile for various values of Dufour number D_f . It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 5(a) exhibits that with the increase in the values of D_f, velocity of the fluid increases in the boundary layer region 0 < η< 5 but no effect is observed from $\eta = 5$ onwards.Fig. 5(b) exhibits that with the increase in the value of D_f, temperature of the fluid increases in the boundary layer region 0 < η< 6 but no effect is observed from $\eta = 6$ onwards. Fig. 5(c) exhibits that with the increase in the value of D_f, concentration of the fluid slightly decreases in the boundary layer region 0 < η< 3 but no effect is observed from $\eta = 3$ onwards.



(a) **(b)** **(c)**

Fig 5: Effect of Dufour number D_f on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

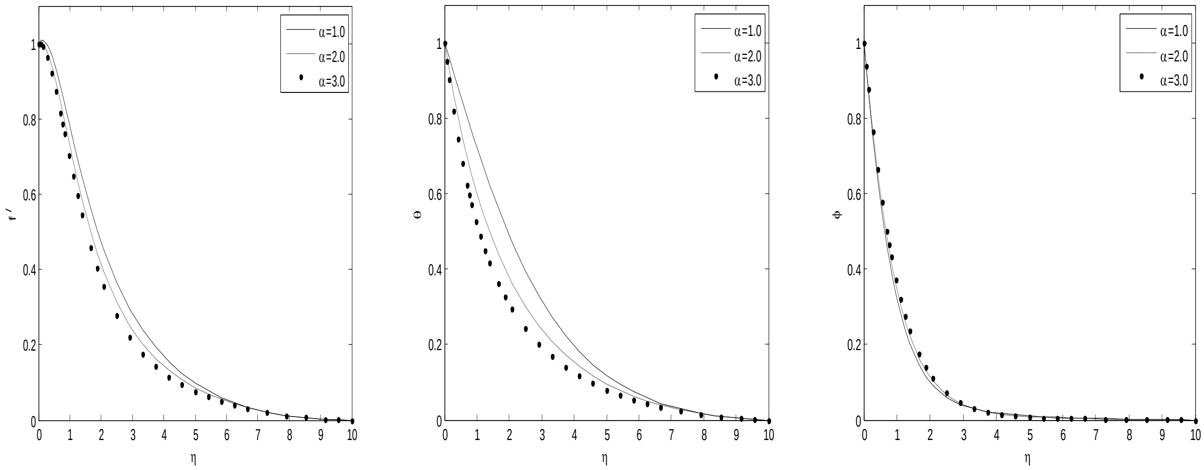
Case 5: Fig. 6(a)-(c) exhibit velocity, temperature and concentration profile for various values of Soret number S_r . It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 6(a) exhibits that with the increase in the values of S_r, velocity of the fluid increases in the boundary layer region $0 < \eta < 6$ but no effect is observed from $\eta = 6$ onwards.Fig. 6(b) exhibits that with the increase in the value of S_r, temperature of the fluid decreases in the boundary layer region $0 < \eta < 8$ but no effect is observed from $\eta = 8$ onwards. Fig. 6(c) exhibits that with the increase in the value of S_r, concentration of the fluid increases in the boundary layer region $0 < \eta < 8$ but no effect is observed from $\eta = 8$ onwards.



(a) **(b)** **(c)**

Fig 6: Effect of Soret number S_r on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

Case 6: Fig. 7(a)-(c) exhibit velocity, temperature and concentration profile for various values of thermal stratification parameter α. It is observed that the velocity, temperature and concentration decrease exponentially from their maximum values at the surface to their minimum values at the end of the boundary layer. Fig. 7(a) exhibits that with the increase in the values of α, velocity of the fluid decreases in the boundary layer region $0 < \eta < 7$ but no effect is observed from $\eta = 7$ onwards. Fig.7(b) exhibits that with the increase in the value of α, temperature of the fluid decreases in the boundary layer region $0 < \eta < 8$ but no effect is observed from $\eta = 8$ onwards. Fig. 7(c) exhibits that with the increase in the value of α, concentration of the fluid slightly increases in the boundary layer region $0 < \eta < 3$ but no effect is observed from $\eta = 3$ onwards.



(a) **(b)** **(c)**

Fig 7: Effect of thermal stratification parameter α on (a) the velocity profile and (b) the temperature profile and (c) the concentration profile

TABLE 1: The values of rate of flow, heat and mass transfer in terms of local skin friction $f''(0)$, local Nusselt number $-\theta'(0)$ and local Sherwood number $-\phi'(0)$ for selected values of K, M, Q, D_f, S_r and α.

K	M	Q	D_f	S_r	α	$f''(0)$	$-\theta'(0)$	$-\phi'(0)$
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
1.0	1.0	0.5	0.5	0.5	1.0	-0.0593	0.2617	1.0442
1.5	1.0	0.5	0.5	0.5	1.0	-0.2589	0.2251	1.0315
0.5	0.5	0.5	0.5	0.5	1.0	0.3986	0.3320	1.0770
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
0.5	1.5	0.5	0.5	0.5	1.0	-0.0593	0.2617	1.0442
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
0.5	1.0	0.8	0.5	0.5	1.0	0.2175	0.1541	1.0941
0.5	1.0	1.0	0.5	0.5	1.0	0.2679	0.0361	1.1214
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
0.5	1.0	0.5	1.0	0.5	1.0	0.1901	0.1792	1.0892
0.5	1.0	0.5	1.5	0.5	1.0	0.2222	0.0529	1.1210
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
0.5	1.0	0.5	0.5	1.0	1.0	0.1649	0.3055	1.0393
0.5	1.0	0.5	0.5	1.5	1.0	0.1719	0.3137	1.0175
0.5	1.0	0.5	0.5	0.5	1.0	0.1586	0.2976	1.0592
0.5	1.0	0.5	0.5	0.5	2.0	0.0889	0.5453	0.9953
0.5	1.0	0.5	0.5	0.5	3.0	0.0407	0.7375	0.9441

IV. Conclusions

In this work, heat source, thermal-diffusion and diffusion-thermal effects on MHD heat and mass transfer over a non-isothermal stretching sheet embedded in a porous medium has been investigated. From our investigation as obvious from table 1 , we can conclude that the rate of flow decreases with increase in permeability parameter, magnetic field parameter and thermal stratification parameter but increases with increase in heat source parameter, Dufour number and Soret number. It can be also concluded from table 1 that the rate of heat transfer decreases in magnitude with increase in permeability parameter, magnetic field parameter, heat source parameter, Dufour number but increases in magnitude with increase in Soret number and thermal stratification parameter. We can also conclude from table 1 that the rate of mass transfer decreases in magnitude with increase in permeability parameter, magnetic field parameter, Soret number and thermal stratification parameter but increases in magnitude with increase in heat source parameter and Dufour number.

REFERENCES

[1] M. A. Seddeek and A. A. Almushigeh, "Effects of radiation and variable viscosity on MHD free convective flow and mass transfer over a stretching sheet with chemical reaction," Applied Mathematics and Computation, 5(1), 2010, 181–197.

[2] R. Kandasamy, T. Hayat, and S. Obaidat, "Group theory trans-formation for Soret and Dufour effects on free convective heat and mass transfer with thermophoresis and chemical reaction over a porous stretching surface in the presence of heat source/sink," Nuclear Engineering and Design, 241(6), 2011, 2155–2161.

[3] D. Pal and B. Talukdar, "Combined effects of Joule heating and chemical reaction on unsteady magnetohydrodynamic mixed convection of a viscous dissipating fluid over a vertical plate in porous media with thermal radiation," Mathematical and Computer Modelling, 54(11-12), 2011,.3016–3036.

[4] A.A.Joneidi, G.Domairry,and M.Babaelahi, "Analytical treatment of MHD free convective flow and mass transfer over a stretching sheet with chemical reaction," Journal of the Taiwan Institute of Chemical Engineers, 41(1), 2010, 35–43.

[5] S.P.Anjalidevi and R.Kandasamy, "Effects of chemical reaction, heat and mass transfer on laminar flow along a semi infinite horizontal plate," Heat and Mass Transfer, 35(6), 1999, 465–467.

[6] M.A.Seddeek, A.A.Darwish,and M.S.Abdelmeguid, "Effects of chemical reaction and variable viscosity on hydromagnetic mixed convection heat and mass transfer for Hiemenz flow through porous media with radiation," Communications in Nonlinear Science and Numerical Simulation, 12(2), 2007, 195–213.

[7] M.S.Abel, S.K.Khan, and K.V.Prasad, "Convective heat and mass transfer in a visco-elastic fluid flow through a porous medium over a stretching sheet," International Journal of Numerical Methods for Heat and Fluid Flow, 11(8), 2001, 779–792.

[8] P. Vyas and N. Srivastava, "Radiative MHD flow over a non-isothermal stretching sheet in a porous medium," Applied Mathematical Sciences, 4(49-52), 2010, 2475–2484.

[9] K. Vajravelu and A. Hadjinicolaou, "Convective heat transfer in an electrically conducting fluid at a stretching surface with uniform free stream," International Journal of Engineering Science, 35(12-13), 1997, 1237–1244.

[10] S. Mohammed Ibrahim and N. Bhaskar Reddy, "Similarity solution of heat and mass transfer for natural convection over a moving vertical plate with internal heat generation and a convective boundary condition in the presence of thermal radiation, viscous dissipation and chemical reaction," ISRN Thermodynamics, 2013.
[11] S. Shateyi, P. Sibanda, and S. S. Motsa, "Magnetohydrodynamic flow past a vertical plate with radiative heat transfer," Journal of Heat Transfer, 129, 2007, 1708–1714.
[12] R. Cortell, "Effects of viscous dissipation and radiation on the thermal boundary layer over a nonlinearly stretching sheet," Physics Letters A: General, Atomic and Solid State Physics, 372(5), 2008 631–636.
[13] M.A.Mansour, "Effects of chemical reaction and thermal stratification on MHD free convective heat and mass transfer over a vertical stretching surface embedded in a porous media considering soret and dufour numbers," the chemical engineering journal, 145(2), 2008, 340-345.
[14] A.M.Aly, M.A.Mansour and A.Chamkha, "Effects of Soret and Dufour numbers on free convection over isothermal and adiabetic stretching surfaces embedded in porous media," Journal of Porous Media, 14(1), 2011, 67-72.
[15] B.R. Sharma and A.Aich, "Influence of Chemical Reaction, Magnetic field and Radiation on Heat and Mass Transfer by Free Convection Flow near the Lower Stagnation Point of an Isothermal Horizontal Circular Cylinder in a Porous Medium considering Soret and Dufour Effects," International Journal of Computer Applications, 116(3), April 2015, 5-11.
[16] B.R.Sharma and D. Borgohain, "Influence of chemical reaction, Soret and Dufour effects on heat and mass transfer of a binary fluid mixture in porous medium over a rotating disk," IOSR Journal of Mathematics, 10(6), Ver. III, Dec 2014 ,73-78.
[17] S.P. Anjali Devi and R. Uma Devi, "Soret and Dufour effects on MHD slip flow with thermal radiation over a porous rotating infinite disk," Communications in Nonlinear Science and Numerical Stimulation, 16(4), April 2011, 1917-1930.
[18] A. Postelnicu, "Influence of chemical reaction on heat and mass transfer by natural convection from vertical surfaces in porous media considering Soret and Dufour effects."Heat Mass Transf, 43, 2007, 595-602.
[19] B.R. Sharma, "Soret and Dufour effects on separation of a binary fluid mixture in MHD natural convection flow in porous media." Mathematical Forum , 24, 2011, 17-27.
[20] S.M. Ibrahim, "Effects of Chemical Reaction on Dissipative Radiative MHD Flow through a Porous Medium over a Nonisothermal Stretching Sheet," Hindawi Publishing Corporation,Journal of Industrial Mathematics, 2014, 1-10.