ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

Effect of Heat Source and Radiation on Unsteady MHD Free Convective Fluid Flow Embedded in a Porous Medium

Dr.Sk.Nuslin Bibi[1], Dr.Padma[2], Ms.S.Lalitha[3], Dr.Mohammed Ali[4], Dr.V.S.Suneetha[5]

Associate Professor, Freshman Engineering Department, Geethanjali College of Engineering and Technology, Hyderabad, India[1,2,3,4], Rayalseema University, Kurnool, India [5]

Abstract: The present research paper aims to study the effect Heat source Radiation effect on an MHD fluid through a vertical fluctuating porous plate. Dimensional non-linear coupled differential equations altered into dimensional less by introducing similarity variables. Time-dependent suction is assumed and the radiative flux is described using the differential approximation for radiation. The Galerkin finite element method is used to sole the equations governing flow. The flow phenomenon has been characterized with the help of flow parameters such as velocity, temperature and concentration profiles for different parameters such as. Schmidt number, Prandtl number, Magnetic field, Heat source, Permeability parameter, Thermal radiation, Chemical reaction, Solutal Grashof number, Soret number, Eckert number and Grashof number. The velocity, temperature and concentration are shown graphically. The coefficient of skin-friction, Nusselt number and Sherwood number are shown in tables.

Keywords: Radiative heat flux, Porous medium, Heat source, MHD, Finite element method.

I. INTRODUCTION

The problem of fluid in an electromagnetic field has been studies for its importance in geophysics, metallurgy and aerodynamic extrusion of plastic sheets and other engineering process such as in petroleum engineering, chemical engineering, composite or ceramic engineering and heat dealing with heat flow and mass transfer over a vertical porous plate with variable suction, heat absorption. The phenomenon of heat and mass transfer is observed in buoyancy induced motions in the atmosphere, in bodies of water, quasi – solid bodies, such as earth and so on. Numerical study on the parabolic flow of MHD fluid past a vertical plate in a porous Medium is studied in [1-2]. In many mass transfer processes, Appearances of MHD three-dimensional flow of nanofluid over a permeable stretching porous [3-4]. Several studies have been carried out on Numerical study of MHD boundary layer flow of a viscoelastic and dissipative fluid past a porous plate in the presence of thermal radiation [5-6], while others have investigated the unsteady cases, such as unsteady MHD convection heat transfer past a semi-infinite vertical porous moving plate with variable suction [7-8]. Raptis [9-10] conversed the Flow of a micro polar fluid past continuously moving plate in presence of radiation. Sunitha et al., [11]. presented Radiation and mass transfer effects on MHD free convective dissipative fluid in the occurrence of heat source/sink. Srinivasa and Anand [12] discussed the Effects of hall current, soret and dufour on an unsteady MHD flow and Heat transfer along a porous flat plate with mass transfer. srihari et al., [13-14] discussed Hall effect on MHD flow along a porous flat plate with Masstransfer and source/sink, Pal and Talukdar [15-16] discussed Buoyancy and chemical reation effects on MHD mixed convection heat and mass transfer in a porous medium with thermal radiation. Vempatati [17] discussed Soret and Dufer effects on unsteady MHD flow past an infinite vertical porous plate with thermal radiation.

In the present paper, effect of thermal radiation, time-dependent suction and chemical reaction on the two-dimensional flow of an incompressible Boussinseq' s fluid in the presence of uniform magnetic field applied normal to the flow has been studied. The problem is governed by the system of coupled non-linear partial differential equations whose exact solutions are difficult to obtain, if possible. so, Galerkin finite element method has been adopted for its solution, which is more economical from computational point view.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

II. NOMENCLATURE

U_o	Mean Velocity
C'	Species concentration
C'_w	Spice concentration near the plate
C'_∞	Spice concentration of the fluid
C	Dimensionless concentration
C_p	Specific heat at constant pressure
g	Acceleration due to gravity
G_Γ	Thermal Grashof number
G_C	Solutal Grashof number
N_Γ	Thermal radiation parameter
K_Γ	Chemical reaction rate content
M	Magnetic field parameter
E_C	Eckert number
P_Γ	Prandtl number
S_C	Schmidt number
S_O	Soret number
Q	Heat source parameter
T'_w	Temperature of the plate
T'_∞	Temperature of the fluid far away from the plate
t'	Time
A	Suction parameter
t	Dimensionless time
u'	Velocity of the fluid in the x -Direction
u_o	Velocity of the plate
u	Dimensionless velocity
y'	Coordinate axis normal to the plate
y	Dimensionless coordinate axis normal to the plate
q'_r	Radiative Flux vector
v	Kinematic viscosity
K	Permeability parameter
β	Coefficient of volume expansion due to temperature
β^*	Coefficient of volume expansion due to Concentration
μ	Coefficient of viscosity
ε	Small reference parameter
ν	Kinematic viscosity
ρ	Density of the fluid
σ_s	Stefan-Boltzmann constant
σ	Electric conductivity
τ'	Skin-friction
τ	Dimensionless skin-friction

III.MATHEMATICAL ANALYSIS

Consider the problem of unsteady two-dimensional, laminar, boundary layer flow of a viscous, incompressible, electrically conducting fluid along a semi-infinite vertical plate in the presence of thermal and concentration buoyancy effects. Time dependent suction is considered normal to the flow. The -axis is taken along the plate in the direction of the flow and -axis normal to it. further, due to the semi-infinite plane surface assumption the flow variables are the functions of normal distances   and   only. A uniform magnetic field is applied normal to the direction of the flow .Now, under the usual Boussinesq's approximation, the governing equations of the flow problem are:

Continuity equation:

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

Momentum equation:

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = g\beta(T' - T'_\infty) + g\beta^*(C' - C'_\infty) + v\frac{\partial^2 u'}{\partial y'^2} - \frac{v}{K'}u' - \frac{\sigma B_0^2}{\rho'}u' \tag{2}$$

Energy Equation:

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = v\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho c_p}\frac{\partial q'_r}{\partial y'} - Q_o(T' - T'_\infty) \tag{3}$$

Concentration Equation:

$$\frac{\partial C'}{\partial t'} + v'\frac{\partial C'}{\partial y'} = v\frac{\partial^2 C'}{\partial y'^2} + \frac{D_m k_T}{T_m}\frac{\partial^2 T'}{\partial y'^2} \tag{4}$$

The boundary conditions for the velocity, temperature and concentration fields are:

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

$$t > 0, u' = 1, T' = T'_\infty + \varepsilon(T'_w - T'_\infty)e^{n't'}, C' = C'_\infty + \varepsilon(C'_w - C'_\infty)e^{n't'} \text{ at } y' = 0$$
$$u' \to 0, T' \to T'_\infty, C' \to C'_\infty, \text{as} \, y' \to \infty \quad (5)$$

Where T'_W and C'_W Dimensional temperature and concentration respectively, and they are the free stream Dimensional temperature and concentration respectively.

The radiative heat flux term by using the Rosseland approximation is given by

$$q'_r = -\frac{4\sigma'}{3k'_1}\frac{\partial T'^4}{\partial y'} \quad (6)$$

All the variables are defined in the nomenclature. It is assumed that the temperature differences within the flow are sufficiently small so that can be expanded in a Taylor series about the free stream temperature so that after rejecting higher order terms:

$$T'^4 \approx 4T'^3_\infty T' - 3T'^4_\infty \quad (7)$$

The energy equation after substitution of Eqs. (6) and (7) can now be written as:

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = \frac{k}{\rho c_p}\frac{\partial^2 T'}{\partial y'^2} + \frac{16\sigma' T'^3_\infty}{3\rho c_p k'}\frac{\partial^2 T'}{\partial y'^2} - Q_o(T' - T'_\infty) + \frac{\nu}{c_p}\left(\frac{\partial u'}{\partial y'}\right)^2 \quad (8)$$

From Eq. (1) one can see that the suction is a function of time only. Hence, it is assumed to be in the following form:

$$v' = -V_O(1 + \varepsilon A e^{n't'}) \quad (9)$$

Where is the suction parameter and $\varepsilon A \ll 1$. Here V_O is mean suction velocity, which is a non-zero positive constant and the minus sign indicates that the suction is towards the plate. It is now convenient to introduce the following dimensionless parameters:

$$u = \frac{u'}{U_o}, y = \frac{U_o y'}{\nu}, t = \frac{t' U_o^2}{\nu}, P_r = \frac{\rho c_p \nu}{k}, S_c = \frac{\nu}{D}, \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty}, \varphi = \frac{C' - C'_\infty}{C'_w - C'_\infty}, K = \frac{K' U_o^2}{\nu^2},$$
$$n = \frac{\nu n'}{U_o^2}, G_r = \frac{g\beta\nu(T'_w - T'_\infty)}{U_o^3}, G_c = \frac{\nu g\beta^*(C'_w - C'_\infty)}{U_o^3},$$
$$Q = \frac{Q_o \nu}{U_o^2}, M = \frac{\sigma B_o^2 \nu}{\rho U_o^2}, K_r^2 = \frac{K_r^2 \nu}{U_o^2}$$
$$S_o = \frac{D_m k_T (T'_w - T'_\infty)}{\nu T_m (C'_w - C'_\infty)}, E_c = \frac{v_o'^2}{C_p(T'_w - T'_\infty)}, N_r = \frac{16\sigma' T'^3_\infty}{3k'k} \quad (10)$$

On substituting of Eq. (9) into Eqs. (2), (4) and (7), the following governing equations are obtained in non-dimensional form:

$$\frac{\partial u}{\partial t} - (1 + \varepsilon A e^{nt})\frac{\partial u}{\partial y} = G_r\theta + G_m\varphi + \frac{\partial^2 u}{\partial y^2} - \left(M + \frac{1}{K}\right)u \quad (11)$$

$$\frac{\partial \theta}{\partial t} - (1 + \varepsilon A e^{nt})\frac{\partial \theta}{\partial y} = \left(\frac{1 + N_r}{P_r}\right)\frac{\partial^2 \theta}{\partial y^2} - Q\theta \quad (12)$$

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

The corresponding boundary conditions are:

$$u = 1, \theta = 1 + \varepsilon e^{nt}, \phi = 1 + \varepsilon e^{nt} \quad on \quad y = 0$$
$$u \to 0, \theta \to 0, \phi \to 0 \quad as \ y \to \infty \quad (14)$$

The mathematical formulation of the problem is now completed. Eqs. (11)-(13) are coupled non-linear systems of partial differential equations, and are to be solved by using the initial and boundary conditions given in eq. (14). However, exact solutions are difficult if possible. Hence these equations are solved by Galerkin finite element method

IV. METHOD OF SOLUTION

Applying the Galerkin finite element method for Eqs. (11) Over the element (*e*) $(y_j \le y \le y_k)$ is :

$$\int_{y_j}^{y_K} N^{(e)T}\left(\frac{\partial^2 u^{(e)}}{\partial y^2} + B\frac{\partial u^{(e)}}{\partial y} - \frac{\partial u^{(e)}}{\partial t} - Nu^{(e)} + R_1\right)dy = 0 \quad (15)$$

Where

$$B = 1 + \varepsilon A e^{nt}, \ R_1 = G_\Gamma\theta + G_m\phi, \ N = M + \frac{1}{K}$$

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

Let the linear piecewise approximation solution

$$u^{(e)} = N_j(y)u_j(t) + N_k(y)u_k(t) = N_j u_j + N_k u_k$$

Where

$$N_j = \frac{y_k - y}{y_k - y_j} \qquad N_k = \frac{y - y_j}{y_k - y_j}$$

$$N^{(e)^T} = \begin{bmatrix} N_j & N_k \end{bmatrix}^T = \begin{bmatrix} N_j \\ N_k \end{bmatrix}$$

The Galerkin expansion for the differential equation (15) becomes

$$N^{(e)^T} \frac{\partial u^{(e)}}{\partial y}\Big\}_{y_j}^{y_K} - \int_{y_j}^{y_K} \left\{ \frac{\partial N^{(e)^T}}{\partial y}\frac{\partial u^{(e)}}{\partial y} - N^{(e)^T}\left(B\frac{\partial u^{(e)}}{\partial y} + \frac{\partial u^{(e)}}{\partial t} + Nu^{(e)} - R_1 \right) \right\} dy = 0 \qquad (16)$$

Neglecting the first term in equation (16) we gets

$$\int_{y_j}^{y_K} \left\{ \frac{\partial N^{(e)^T}}{\partial y}\frac{\partial u^{(e)}}{\partial y} - N^{(e)^T}\left(B\frac{\partial u^{(e)}}{\partial y} - \frac{\partial u^{(e)}}{\partial t} - Nu^{(e)} + R_1 \right) \right\} dy = 0$$

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

Where $l^{(e)} = y_k - y_j = h$ and dot denotes the differentiation with respect to t.

We write the element equations for the elements $y_{i-1} \le y \le y_i$ and $y_j \le y \le y_k$ assemble three element equations, we obtain

$$\frac{1}{l^{(e)^2}}\begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}\begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} - \frac{B}{2l^{(e)}}\begin{bmatrix} -1 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & 1 \end{bmatrix}\begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} + \frac{1}{6}\begin{bmatrix} 2 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix}\begin{bmatrix} \dot{u}_{i-1} \\ \dot{u}_i \\ \dot{u}_{i+1} \end{bmatrix} + \frac{N}{6}\begin{bmatrix} 2 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix}\begin{bmatrix} u_{i-1} \\ u_i \\ u_{i+1} \end{bmatrix} = \frac{R_1}{2}\begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} \qquad (17)$$

Now put row corresponding to the node *i* to zero, from equation (17) the difference schemes are

$$\frac{1}{l^{(e)^2}}[-u_{i-1} + 2u_i - u_{i+1}] - \frac{B}{2l^{(e)}[\ ]}[-u_{i-1} + u_{i+1}] + \frac{1}{6}[\dot{u}_{i-1} + 4\dot{u}_i + \dot{u}_{i+1}] + \frac{N}{6}[u_{I-1} + 4u_i + u_{i+1}] = R_1 \qquad (18)$$

Where

$$A_1 = 2 - 6r + 3Brh + Nk$$
$$A_2 = 8 + 12r + 4Nk$$
$$A_3 = 2 - 6r - 3Brh + Nk$$
$$A_4 = 2 + 6r - 3Brh - Nk$$
$$A_5 = 8 - 12r - 4Nk$$
$$A_6 = 2 + 6r + 3Brh - Nk$$
$$R^* = 12(G_\Gamma)k\theta_i^j + 12(G_m)k\phi_i^j$$

Applying similar procedure to equation (12) and (13) then we gets

$$B_1\theta_{i-1}^{j+1} + B_2\theta_i^{j+1} + B_3\theta_{i+1}^{j+1} = B_4\theta_{i-1}^j + B_5\theta_i^j + B_6\theta_{i+1}^j \qquad (19)$$

$$C_1\phi_{i-1}^{j+1} + C_2\phi_i^{j+1} + C_3\phi_{i+1}^{j+1} = C_4\phi_{i-1}^j + C_5\phi_i^j + C_6\phi_{i+1}^j \qquad (20)$$

Where

$$B_1 = 2 - 6Dr + 3Brh + Qk$$
$$B_2 = 8 + 12Dr + 4Qk$$
$$B_3 = 2 - 6Dr - 3Brh + Qk$$
$$B_4 = 2 + 6Dr - 3Brh - Qk$$
$$B_5 = 8 - 12Dr - Qk$$
$$B_6 = 2 + 6Dr + 3Brh - Qk$$
$$R^{**} = 12rE_C(u[i+1] - u[i])^2$$
$$C_1 = 2S_c - 6r + 3BS_crh + ES_ck$$
$$C_2 = 8S_c + 12r + ES_ck$$
$$C_3 = 2S_c - 6r - 3BS_crh + ES_ck$$
$$C_4 = 2S_c + 6r - 3BS_crh - ES_ck$$
$$C_5 = 8S_c - 12r - 4ES_ck$$
$$C_6 = 2S_c + 6r + 3BS_crh - ES_ck$$
$$R^{***} = 12rS_CS_o(\theta[i-1] - 2\theta[i] + \theta[i+1])$$

Here $r = \frac{k}{h^2}$, $D = \frac{1 + N_\Gamma}{P_\Gamma}$, $E = K_\Gamma^2$ and h, k are the mesh sizes along y-direction and time t-direction respectively. Index i refers to the space and j refers to the time. In Equations (18)-(20), taking i = 1(1) n and using initial and boundary conditions (14), the following system of equations are obtained:

$$A_i X_i = B_i \qquad i = 1(1)3 \qquad (21)$$

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 using Thomas algorithm for velocity, temperature and concentration. Also, numerical solutions for these equations are obtained by C-program. In order to prove the convergence and stability of finite element method, the same C-program was run with slightly changed values of h and k and no significant change was observed in

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

the values of u, θ and ϕ . Hence, the finite element method is stable and convergent.

SKIN FRICTION

The skin-friction, Nusselt number and Sherwood number are important physical parameters for this type of boundary layer flow. The skin friction, rate of heat and mass transfer are

Skin-friction coefficient (C_f) is given by

$$C_f = \left(\frac{\partial u}{\partial y}\right)_{y=0} \quad (22)$$

Nusselt number (Nu) at the plate is

$$Nu = \left(\frac{\partial \theta}{\partial y}\right)_{y=0} \quad (23)$$

Sherwood number (Sh) at the plate is $Sh = \left(\frac{\partial \phi}{\partial y}\right)_{y=0}$

(24)

V. RESULTS AND DISCUSSION

The formulation of the problem that accounts for the effects of the chemical reaction on an unsteady MHD flow past a semi-infinite vertical porous plate with viscous dissipation is performed in the preceding sections. The governing equations of the flow field are solved analytically by using a finite element method. The expressions for the velocity, temperature, concentration, skin-friction, Nusselt number, and Sherwood number are obtained. To get a physical insight of the problem, the above physical quantities are computed numerically for different values of the governing parameters, viz., the thermal Grashof number G_Γ, the solutal Grashof number G_m, the magnetic parameter M ,the thermal radiation the permeability parameter K, the Prandtl number P_Γ, the heat source parameter Q, the Eckert number E_C, the Schmidt number S_C , the chemical reaction parameter K_Γ , the soret number S_O , Here we fixed $\varepsilon = 0.02, n = 0.5, t = 1.0$

Figs 1(a) and 1(b) illustrate the velocity and temperature profiles for different values of Heat source parameter Q , the numerical results show that the effect of increasing values of heat source parameter result in a decreasing velocity and temperature.

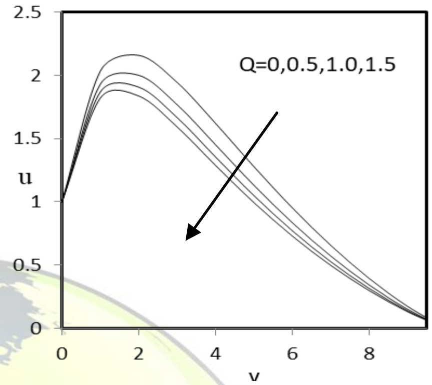


Fig.1(a). Effects of Q on Velocity.

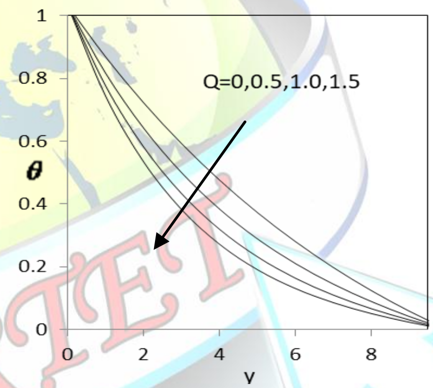
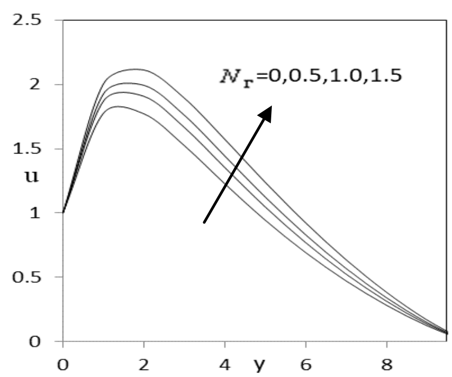


Fig.1(b). Effects of Q on Temperature.

Figs 2(a) and 2(b) illustrates the behaviour Velocity and Temperature for different values of Thermal radiation parameter N_Γ . It is observed that an increase in N_Γ contributes to increase in both the values of velocity and Temperature.



ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

Fig.2(a). Effects of N_Γ on Velocity

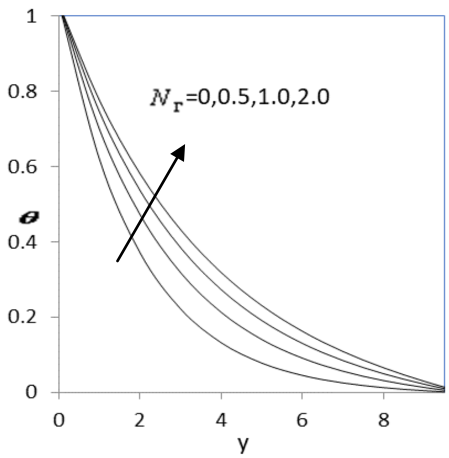


Fig.2(b). Effects of N_Γ on Temperature.

The influence of the thermal Grashof number G_Γ on the velocity is presented in figure .3. Increase in the Grashof number contributes to the increase in velocity when all other parameter that appears in the velocity field are held constant The influence of the solutel Grashof number Gm on the velocity is presented in figure.4.It is observed that, while all other parameters are held constant and velocity increases with an increase in solute Grashof number G_m.

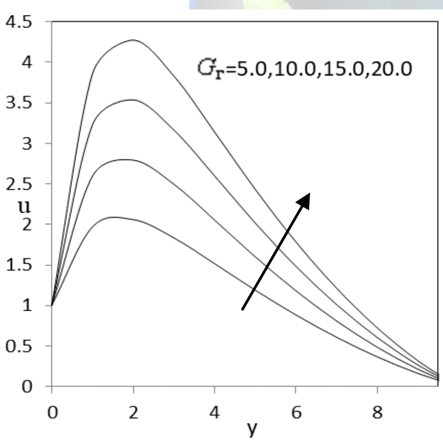


Fig.3.Effects of G_Γ on Velocity

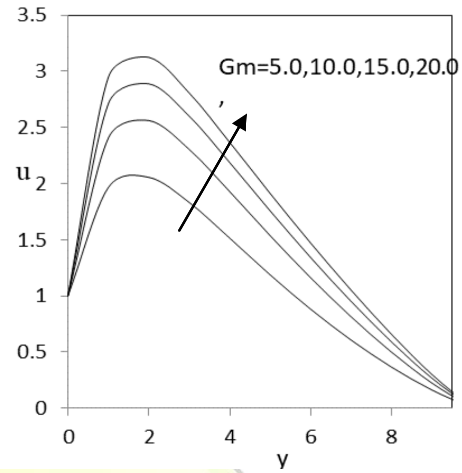


Fig.4.Effects of G_m on Velocity

Figs 5(a) and 5(b) illustrate the velocity and temperature profiles for different values of the Prandtl number P_Γ. The Prandtl number defines the ratio of momentum diffusivity to thermal diffusivity. The numerical results show that the effect of increasing values of Prandtl number results in a decreasing velocity (Fig 5(a)). From Fig 5 (b), it is observed that an increase in the Prandtl number results a decrease of the thermal boundary layer thickness and in general lower average temperature within the boundary layer.

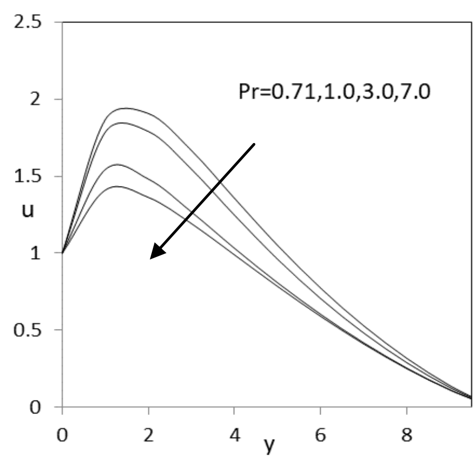


Fig.5.Effets of P_Γ on Velocity

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

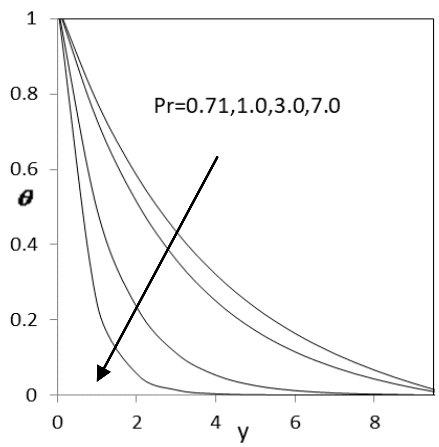


Fig.5.Effets of on Temperature

For various values of the magnetic parameter M, the velocity profiles are plotted in Fig 6. It can be seen that as M increases, the velocity decreases. This result qualitatively agrees with the expectations, since the magnetic field exerts a retarding force on the flow.

The effect of the permeability parameter on the velocity field is shown in Fig 7. An increase in the resistance of the porous medium which will tend to increase the velocity.

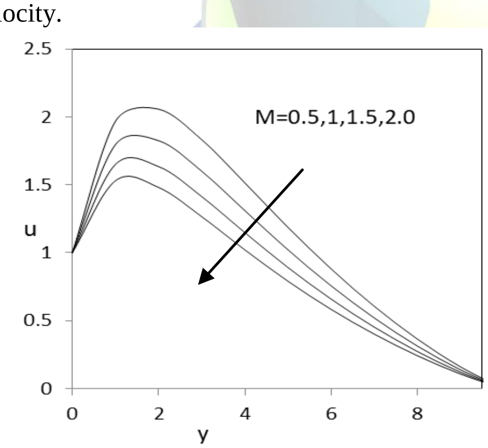


Fig.6.Effets of M on Velocity

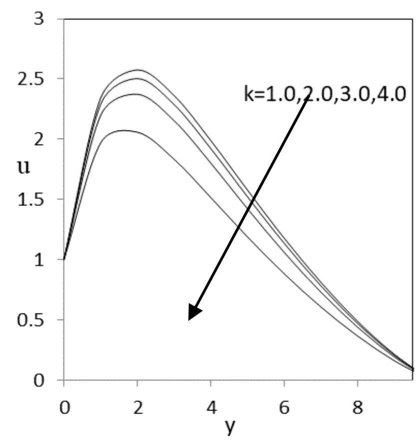


Fig.7.Effects of on Velocity.

Figs 8(a) and 8(b) respectively. The Schmidt number embodies the ratio of the momentum to the mass diffusivity. The Schmidt number S_C therefore quantifies the relative effectiveness of momentum and mass transport by diffusion in the hydrodynamic (velocity) and concentration (species) boundary layers. As the Schmidt number S_C increases the concentration and velocity decreases.

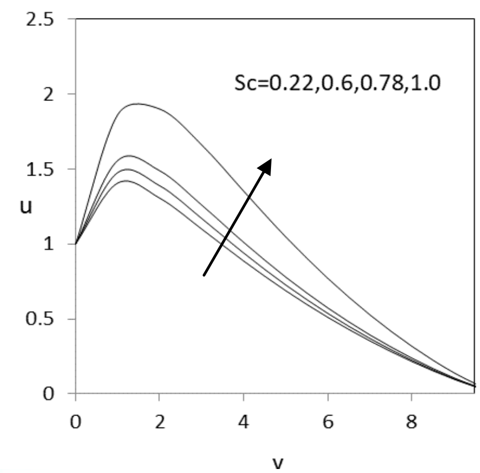


Fig.8(a). Effects of S_C on Velocity

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

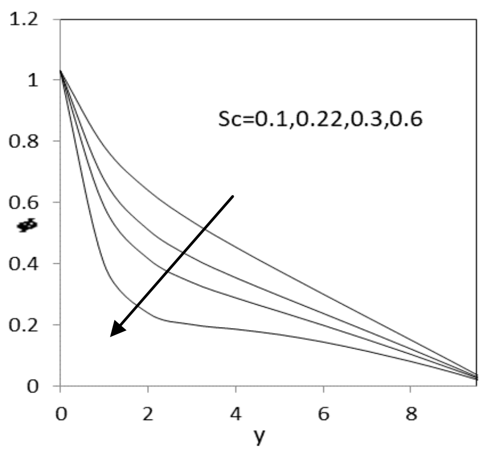


Fig.8(b). Effects of on Concentration

Figs 9(a) and9(b) describe the velocity and concentration profiles for diverse values of the Soret number S_O. The Soret number defines the ratio of temperature difference to the concentration It is noticed that a growth in the Soret number reduction in the velocity and concentration within the boundary layer.

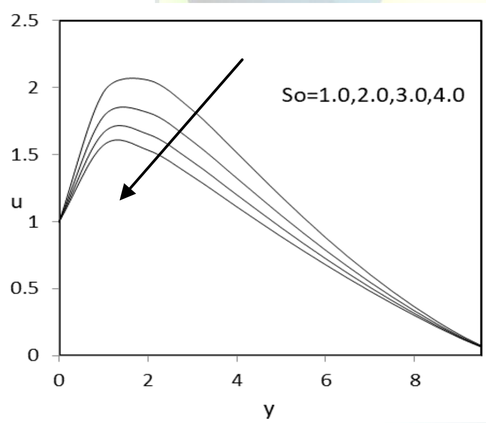


Fig.9(a). Effects of on velocity

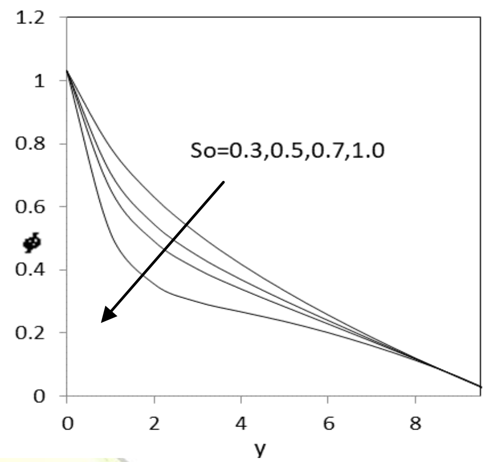


Fig.9(b). Effects of on Concentration

The effects of several governing parameters on the skin friction coefficient, Nusselt number and the Sherwood number are shown in Tables 1, 2 and 3. From Table 1, it is noticed that as G_Γ or G_m increases, the skin friction coefficient increases. It is obvious that as M or K increases, the skin friction coefficient decreases. From Table 2, it is noticed that rise in the Q or the Prandtl number reduces the skin friction and increases the Nusselt number. Also, it is found that as and increases the skin friction increases and the Nusselt number increases. From Table 3, it is found that as increases, the skin friction coefficient reduced and the Sherwood number decreases. Also, it is found that as increases the skin friction growth and the Sherwood number increases.

Table 1: Effect of G_Γ ,Gm , M and K on C_f

(N_Γ =0.5, Q =1.0, $\Pr$ =0.71, Ec =0.001, Sc =0.22,

So =1.0, K_Γ =0.5)

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

G_{Γ}	Gm	M	K	C_f
5.0	5.0	0.5	1.0	3.7681
10.0	5.0	0.5	1.0	4.9583
5.0	10.0	0.5	1.0	4.2746
5.0	5.0	1.0	1.0	2.3275
5.0	5.0	0.5	2.0	2.9958

Table 2: Effect of Q, $\Pr$, N_{Γ} and Ec on C_f and Nu

(G_{Γ} =5.0, Gm =5.0, M =0.5, K =1.0, Sc =0.22, So =1.0)

Q	Pr	N_{Γ}	C_f	Nu
1.0		0.5	3.7681	1.6513
2.0	0.71	0.5	3.1542	1.5324
1.0	0.71	0.5	2.8564	1.1258
1.0	7.0	1.0	4.2654	2.5413
1.0	0.71	0.5	3.8916	1.8645

Table 3: Effect of Sc, So and K_{Γ} on C_f and Sh

(G_{Γ} =5.0, Gm =5.0, M =0.5, K =1.0, Q =1.0, $\Pr$ =0.71, N_{Γ} =0.5)

Sc	So	C_f	Sh
0.22	1.0	3.7681	1.4256
0.60	1.0	3.2132	1.2546
0.22	2.0	3.9245	1.6524
0.22	1.0	3.1542	1.0984

VI. CONCLUSION

The problem of two-dimensional fluid in the prances of thermal and concentration buoyancy effects under the influence of uniform magnetic field applied normal to the flow is formulated and solved numerically. A Galerkin finite element method is adopted to solve the equations governing the flow. The results illustrate the flow characteristics for the velocity, temperature, concentration, skin-friction, Nusselt number, and Sherwood number. The conclusions of the study are as follows:

1.Increasing in the velocity number substantially increase in the Thermal Grashof number and Solutal Grashof number.
2.Decreasing in the velocity with an increase in the Magnetic parameter.
3.Increase in the Permeability of the porous medium parameter with increases in velocity.
4.Increasing the Prandtl number substantially decreases the translational velocity and the temperature function.
5.As the Heat source parameter increases both velocity and temperature decreases.
6.As velocity and temperature rise with reduce in the Thermal radiation parameters.
7.Increase in the Schmidt number the velocity as well as concentration reduce.
8.As rise in the Soret number leads to reduce in the velocity and temperature.
9.As rise in the Chemical reaction the velocity as well as concentration reduce.

ACKNOWLEDGMENT

I would like to express my appreciation to Geethanjali College of Engineering and Technology for their unwavering support throughout this research endeavour. Their encouragement and belief in the significance of this work were truly motivating. Finally, I want to thank my family and my colleagues for their understanding, and support during the challenging periods of this research.

REFERENCES

[1] Chamkha, A.J., *Unsteady MHD convective heat and mass transfer past a semi-infinite vertical permeable moving plate with heat absorption*., Int. Journal of Engineering Science.,42, 217-230.2004

[2] M.C. Raju., *Buoyancy effects on chemically reactive magneto-nanofluid past a moving vertical plate*, Bulletin of Pure and Applied Sciences. 38E (1) (2019) 193-207.

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 11, Issue 1, January 2024

[3] **G. Sivaiah**., *Numerical study of MHD boundary layer flow of a viscoelastic and dissipative fluid past a porous plate in the presence of thermal radiation*, International Journal of Fluid Mechanics Research, 46(1) (2019) 27–38.https://doi.org/10.1063/5.0014572

[4] Poli Chandra Reddy., *Characteristics of MHD three-dimensional flow of nanofluid over a permeable stretching porous sheet*, *Heat Transfer*, 51(4) 3586-3599

[5] U.J.Das., *Analytical study of buoyancy effects on MHD visco-elastic fluid past an inclined plate*, AIP Conference Proceedings2246, 020072 (2020) 020072-1-020072-7

[6] Dr P Chandra Reddy., *Convective heat transfer and mass transfer observations of MHD Cu-water nanofluid in a rotating system*, AIP Conference Proceedings2246, 020068 (2020) 020068-1-020068-7

[7] R.M.Kannan., *Unsteady MHD free convective flow of a radiating fluid past an inclined permeable plate in the presence of heat source*, AIP Conference Proceedings2246, 020086 (2020) 020086-1-020086-8

[8] Chen., *Combined heat and mass transfer in MHD free convection from a vertical surface with Ohmic heating and viscous dissipation*., Acta Mechanica,172, 217-230.

[9] Ogulu ,A., & Mbeledogu, I. U., 2007. *Heat and mass transfer of an unsteady MHD natural convection flow of a rotating fluid past a vertical transfer*., Int J. Heat Mass Transfer, 50, 1902-1911.

[10] Pal, D. and Talukdar, B., 2010. *Buoyancy and chemical reation effects on MHD mixed convection heat and mass transfer in a porous medium with thermal radiation*. Nonlinear Sci. Numer. Simulate.,15(10), 2878-2893.

[11] Pilani, G., & Abbas, I.A., 2009. *Free convection MHD flow with thermal radiation from an impulsively started vertical plate*. Nonlinear Analysis Modelling and Control,14,73-84.

[12] Prakash, J., Ogulu, A., & Zhandire, E., 2008. *MHD free convection and mass transfer flow of a micro-polar thermally radiating and reacting fluid with time dependent suction*., Indian J Pure Appl Phys ,46, 679-685.

[13] Srihari K,Kishan, N., & Anand Rao, J., 2008. *Hall effect on MHD flow along a porous flat plate with Masstransfer and source/sink*., J Energy Heat & Mass Transfer, 30,361-375.

[14] Srinivasa raju,R., & Anand Rao, J., 2011. *Effects of hall current, soret and dufour on an unsteady MHD flow and Heat transfer along a porous flat plate with mass transfer*., J Energy Heat & Mass Transfer, 33,313-332.

[15] Sunitha, S., Bhasker Reddy, N., & Ram Chandra Prasad, V., 2011. *Radiation and mass transfer effects on MHD free convective dissipative fluid in the prances of heat source/sink*., J. of Appl. Fluid Mechanics, 4,107-113.

[16] Tasawar Hayat & Zaheer Abbas., 2008. *Radiation effects on MHD flow in porous space.*, Int J Heat Mass Transfer,51, 1024-1033.

[17] Vempatati, S.R., and Laxmi narayana gari,A.B., 2010. *Soret and Dufer effects on unsteady MHD flow past an infinite vertical porous plate with thermal radiation.*, Appl. Meth. Mech. – Engl. Ed.,31, 1481-1496.

