Hall Current and Radiation Effects on MHD Free Convective Heat and Mass Transfer Effects on Unsteady Flow Past an infinite Vertical Porous Plate embedded in Porous Medium in Presence Heat Source with Chemical Reaction

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Abstract: In the present paper, Hall Effects with Radiation effects on unsteady free convection flow and mass transfer over an infinite vertical porous plate which is embedded in porous medium with heat source. The basic governing equations of the problem are transformed into a system of non dimensional differential equations, which are then solved analytically by using Perturbation techniques. The dimensionless Velocity, temperature and concentration profiles are displayed graphically showing the effects fluid flow for the different values of the parameters involving in this problem like permeability parameter Kp,Grashof numbers Gr, Gc for heat and mass transfer, Heat Source parameter (S),Schmidt Number(Sc),Prandtl Number (Pr),Radiation Parameter(R) Second Order Chemical reaction parameter (Kr^2) etc.,. It is interesting to note that an increase of Grashof number(Gr),Permeability parameter(Kp) Grashof Number (Gc) accelerates the transient velocity of fluid.But increase of Heat Source parameter (S)retards the velocity profile of fluid flow.Further, it is observed that the temperature profile of the fluid flow decrease while increasing of prandtl number(Pr) and Radiation Parameter(R).But increase of Grashof number(Gr),shows the reverse process.The effect of increasing Schmidt number(Sc) and Chemical reaction parameter (Kr^2) is to decrease the concentration boundary layer thickness of the flow field.Further, a growing of Magnetic Parameter (M) and Hall Parameter (m) increasing the skin friction at the wall expect (Pr=5) and growing of Magnetic Parameter (M) and Hall Parameter (m) leads to increase the magnitude of the rate of heat transfer at the wall expect (Pr=0.71).While Chemical reaction parameter (Kr^2) increase, shows the decrease effects of the rate of mass transfer at the wall.The investigated results showed graphically that the flow field is notably influenced by the considering parameters.

Keywords: Heat Transfer, Mass Transfer, Porous Medium, Hall Effects, Radiation Parameter, Chemical Reaction.

1.INTRODUCTION

The Influence of Magnetic field on viscous incompressible flow of electrically conductor fluid has its important in many application such as extrustion of plastics in manufacture of rayon and nylon, purification of crude oil, paper industry, textile industry, etc., In Engineering in MHD pumps, MHD bearing etc., at high temperature attained in some Engineering devices, gas, for example can be ionized and so become an electrical conductor. However, in the presence of strong electric field, the electrical conductive is affected by magnetic field. Consequently, the conductivity parallel to electric field is reduced. Hence, the current is reduced to the direction normal to both electric and magnetic fields. This phenonmenon is known as Hall Effect. Gebhart B and Pera L[1] has discuss the nature of vertical natural convection flows resulting from combined buoyancy effects of thermal and mass diffusion.
Gersten K. and Gross J.F.[2] study the nature flow along a plane with heat transfer and periodic suction. G.Ram and R.S Mishra[3] analysis of MHD flow of conducting fluid through porous media. Three dimensional coutte flow deeply analysis with various parameter by Singh P., Sharma V.P and Mishra U.N

[4]. M.M. Alam and M.A Sattar[5] has discussed the nature of Energy, Heat and Mass transfer while the fluid flow along a plate. EM.Aboeldahab and EME.Elbarbary[6] analysis of Hall current effects on Magneto-hydrodynamics free convection flow past a semi-infinite vertical plate with mass transfer. Chamkha and Khaled[7] analysis of Simultaneous heat and mass transfer in free convection fluid flow. Angel et al[8]., were discuss the nature of Combined heat and mass transfer of fluid flow over an inclined plane with natural convection. Fang T[9] analysis deeply the similarity solutions for a moving flat plate with thermal boundary layer. Marek Behr [10] analysis the application of the slip boundary condition on curved curve with various parameter. Hossain et.al.,[11], analysis the heat generation while the fluid flow by Natural Convection flow. A.Mehmood and A.Ali[12] analysis the results of Effect of slip condition on unsteady MHD oscillatory flow of a viscous fluid in a planar channel. K.D.Singh and A. Mathew[13] very deeply discuss the effects of Injection/suction effect on an oscillatory hydromagnetic flow in a rotating horizontal porous channel. Kishan N.,Srinivas M.[14] Analaysis of fluid flow with slip boundary conditions. G.S. Seth., R.Nandkeolyar and Md.S.Ansari. Unsteady[15] were discuss the nature of MHD convective flow within a parallel plate rotating channel with thermal source/sink in a porous medium under slip boundary conditions.

In the view of all such studies, the present paper is to analyze the effects of hall current on unsteady MHD free convective heat and mass transfer flow past an infinite vertical porous plate embedded in porous medium with second order chemical reaction and heat source. The Problem is governed by the system of coupled non-linear partial differential equations whose exact solutions are difficult to obtain, so we use Perturbation Techniques for obtained solution, which is more economical from computational point of view. The behavior of Velocity, temperature, Concentration, shearing stress, Nusselt Number and Sherwood Number has been discussed for variation in the govering parameters.

2.FORMULATION OF THE PROBLEM

In the this problem, it can be considered that the flow is unsteady natural convection and mass transfer flow of a viscous incompressible fluid past an infinite vertical porous plate which is embedded in porous medium with heat source. The x' axis is taken in vertically upward direction along the plate and y' axis is chosen normal to it. Neglecting the Joulean heat dissipation and applying Boussinesq's approximation the governing equations of the flow field are written as follows:

Continuity Equation:

$$\frac{\partial v'}{\partial y'} = 0\,;\;\; v' = -v'_0(Constant) \qquad (1)$$

Momentum Equation:

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = \nu\frac{\partial^2 u'}{\partial y'^2} + g\beta(T' - T_\infty') + g\beta^*(C' - C_\infty') - \frac{\sigma B_0{}^2}{\sigma(1+m^2)} - \frac{\nu}{K'}u' \qquad (2)$$

Energy Equation:

$$u'\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = k\,\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho C_p}\frac{\partial q_r}{\partial y'} + \frac{\vartheta}{Cp}\left(\frac{\partial u'}{\partial y'}\right)^2 + S'(T' - T_\infty') \qquad (3)$$

Concentration Equation

$$\frac{\partial C'}{\partial t'} + v'\frac{\partial C'}{\partial y'} = D\frac{\partial^2 C'}{\partial y'^2} - Kr'^2(C' - C_\infty') \qquad (4)$$

The local radiant for the case of the optically thin gray gas is expressed as

$$\frac{\partial q_r}{\partial y'} = -4a^*\sigma(T_\infty'^4 - T'^4) \qquad (5)$$

It is assumed that the temperature differences within the flow are sufficiently small so that T'^4 can be expressed in a Taylor Series about the free Stream Temperature T_∞' so that after rejecting the higher order terms

$$T'^4 = 4T_\infty'^3T' - 3T_\infty'^4 \qquad (6)$$

The Energy Equation after substitution of equations (*) and (**) can be written as

$$u'\frac{\partial T'}{\partial t'}+v'\frac{\partial T'}{\partial y'}=k\ \frac{\partial^2 T'}{\partial y'^2}+\frac{16a^*\sigma T_\infty'^3}{\rho C_p}(T_\infty'-T')-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial y'}+\frac{\vartheta}{Cp}\left(\frac{\partial u'}{\partial y'}\right)^2+S'(T'-T_\infty') \quad (4a)$$

Boundary Conditions are:

$$u'=0, v'=-v_0', T'=T_w'+\varepsilon(T_w'-T_\infty')e^{i\omega' t'}, C'=C_w'+\varepsilon(C_w'-C_\infty')e^{i\omega' t'}\ \ at\ y'=0$$
$$u'\to 0, T'\to T_\infty', C'\to C_\infty'\ \ as\ y'\to\infty \quad (7)$$

Now, Introducing the following non- dimensional variables and parameters.

$$y=\frac{y'v'_0}{\vartheta},\ t=\frac{t'v'^2_0}{4\vartheta},\ \omega=\frac{4\vartheta\omega'}{v'^2_0},\ u=\frac{u'}{v'_0},\ \vartheta=\frac{\eta_0}{\rho}, K_p=\frac{v'^2_0K'}{\vartheta^2}, T=\frac{T'-T_\infty'}{T'_w-T_\infty'}, C=\frac{C'-C_\infty'}{C_w'-C_\infty'}$$

$$P_r=\frac{\vartheta}{k},\quad Gr=\frac{\vartheta g\beta(T'_w-T_\infty')}{v'^3_0},\ Gc=\frac{\vartheta g\beta(T'_w-T_\infty')}{v'^3_0}, Sc=\frac{\vartheta}{D}, S=\frac{4S'\vartheta}{v'^2_0}, Ec=\frac{v'^2_0}{Cp(T'_w-T_\infty')},$$

$$K_r^2=\frac{K_r'^2\vartheta}{\vartheta_0^2}, M_1=\frac{M}{1+m^2}+\frac{1}{Kp},\quad R=\frac{16a^*\sigma T_\infty'^3\vartheta}{\rho C_p v'^2_0} \quad (8)$$

Where $g, \rho, \vartheta, \beta, \beta^*, \omega, \eta_0, k, T', T'_w, T'_\infty, C', C_w', C_\infty', Cp, D, Pr, Sc, Gr, Gc, S, Kp, Ec\ and\ K_r$ are respectively the acceleration due to gravity, density, coefficient of kinematic viscosity, volumetric coefficient of expansions for heat transfer,volumetric coefficient of expansions for mass transfer, angular frequency,Coefficient of viscosity, thermal diffusivity, temperature, temperature at the plate, temperature at infinity,Concentration, Concentration at the plate, concentration at infinity, specific heat at constant pressure,molecular mass diffusivity,Prandtl number,Schmidt number, Grashof number for heat transfer, Grahof number for mass transfer, heat source parameter, permeability parameter, Eckert number and Chemical reaction parameter.

Substituting equation (6) in equations (2),(3), and (4) under boundary conditions (5) we get

$$\frac{1}{4}\frac{\partial u}{\partial t}-\frac{\partial u}{\partial y}=\frac{\partial^2 u}{\partial y^2}+GrT+Gc-M_1u \quad (9)$$

$$\frac{1}{4}\frac{\partial T}{\partial t}-\frac{\partial T}{\partial y}=\frac{1}{Pr}\frac{\partial^2 T}{\partial y^2}+\frac{1}{4}(S+4R)T++Ec\left(\frac{\partial u}{\partial y}\right)^2 \quad (10)$$

$$\frac{1}{4}\frac{\partial C}{\partial t}-\frac{\partial C}{\partial y}=\frac{1}{Sc}\frac{\partial^2 C}{\partial y^2}-Kr^2c \quad (11)$$

The Corresponding boundary conditions are:

$$u=0, T=1+\varepsilon e^{i\omega t}, C=1+\varepsilon e^{i\omega t}\ \ at\ \ y=0$$
$$u\to 0, T\to 0, C\to 0\ \ as\ y\ \to\infty \quad (12)$$

3.METHOD OF SOLUTION

To solve equations (7), (8) and (9) , we assume ε to be small and the velocity,temperature and concentration distribution of the flow field in the near of the plate as

$$u(y,t)=u_0(y)+\varepsilon e^{i\omega t}u_1(y) \quad (13)$$
$$T(y,t)=T_0(y)+\varepsilon e^{i\omega t}T_1(y) \quad (14)$$
$$C(y,t)=C_0(y)+\varepsilon e^{i\omega t}C_1(y) \quad (15)$$

Substituting equations (11) – (13) in equations (7) –(9) respectively, equating harmonic and nonharmonic terms and the neglecting the coefficients of ε^2 then we get

$$u_0''+u_0'-M_1u_0=-GrT_0-GcC_0 \quad (16)$$

$$T_0''+PrT_0'+\frac{Pr}{4}(S+4R)T_0=-PrEc\left(\frac{\partial u_0}{\partial y}\right)^2 \quad (17)$$

$$C_0''+ScC_0'-ScK_r^2C_0=0 \quad (18)$$

First Order:

$$u_1''+u_1'-\left(\frac{i\omega}{4}+M_1\right)u_1=-GrT_1-GcC_1 \quad (19)$$

$$T_1''+PrT_1'-\frac{Pr}{4}(i\omega-(S+4R)T_1=-2PrEc\left(\frac{\partial u_0}{\partial y}\right)\left(\frac{\partial u_1}{\partial y}\right) \quad (20)$$

$$C_1'' + ScC_1' - Sc\left(\frac{i\omega}{4} + K_r^2\right)C_1 = 0 \tag{21}$$

The Corresponding boundary conditions are

$y = 0: u_0 = 0, T_0 = 1, C_0 = 1, u_1 = 0, T_1 = 1, C_1 = 1$

$$y \to \infty: u_0 = 0, T_0 = 0, C_0 = 0, u_1 = 0, T_1 = 0, C_1 = 0 \tag{22}$$

Solving equations (16) & (19) under the boundary condition (20), then we get

$$C_0 = e^{M_2 y} \tag{23}$$

$$C_1 = e^{M_4 y} \tag{24}$$

Using Multi parameter perturbation technique and assuming Ec≪ 1, we take

$$u_0(y) = u_{00}(y) + Ecu_{01} \tag{25}$$

$$T_0 = T_{00} + EcT_{01} \tag{26}$$

$$u_1 = u_{10} + Ecu_{11} \tag{27}$$

$$T_1 = T_{10} + EcT_{11} \tag{28}$$

Now using equations (25) –(28) in equations (13),(14) and (15) and equating the coefficients of like powers of Ec neglecting of Ec^2, we get the following set of differential equations.

Zeroth Order:

$$u_{00}'' + u_{00}' - M_1 u_{00} = -GrT_{00} - GcC_0 \tag{29}$$

$$u_{10}'' + u_{10}' - \left(\frac{i\omega}{4} + M_1\right)u_{10} = -GrT_{10} - GcC_1 \tag{30}$$

$$T_{00}'' + PrT_{00}' + \frac{Pr}{4}(S + 4R)T_{00} = 0 \tag{31}$$

$$T_{10}'' + PrT_{10}' - \frac{Pr}{4}(i\omega - (S + 4R))T_{10} = 0 \tag{32}$$

The Corresponding boundary conditions are

$y = 0: u_{00} = 0, T_{00} = 1, U_{10} = 0, T_{10} = 1$

$$y \to \infty: u_{00} = 0, T_{00} = 0, U_{10} = 0, T_{10} = 1 \tag{33}$$

First Order:

$$u_{01}'' + u_{01}' - M_1 u_{01} = -GrT_{01} \tag{32}$$

$$u_{11}'' + u_{11}' - \left(\frac{i\omega}{4} + M_1\right)u_{11} = -GrT_{11} \tag{33}$$

$$T_{01}'' + PrT_{01}' + \frac{Pr}{4}(S + 4R)T_{01} = -Pr(u_{00}')^2 \tag{34}$$

$$T_{11}'' + PrT_{11}' - \frac{Pr}{4}(i\omega - (S + 4R))T_{11} = -2Pr\left(\frac{\partial u_{00}}{\partial y}\right)\left(\frac{\partial u_{10}}{\partial y}\right) \tag{35}$$

The Corresponding boundary conditions become,

$y = 0: u_{01} = 0, T_{01} = 0, u_{11} = 0, T_{11} = 0$

$$y \to \infty: u_{01} = 0, T_{01} = 0, u_{11} = 0, T_{11} = 0 \tag{36}$$

Solving equations (27)-(30) subject to the boundary conditions (31) we get

$$u_{00} = A_{10}e^{M_{10}y} + A_{11}e^{M_6 y} + A_{12}e^{M_2 y} \tag{37}$$

$$T_{00} = e^{M_6 y} \tag{38}$$

$$u_{10} = A_{14}e^{M_{12}y} + A_{15}e^{M_8 y} + A_{16}e^{M_4 y} \tag{39}$$

$$T_{10} = e^{M_8 y} \tag{40}$$

Solving equations (32)-(35) subject to boundary conditions (36) we get

$$T_{01} = A_{18}e^{M_{14}y} + B_1 e^{2M_{10}y} + B_2 e^{2M_6 y} + B_3 e^{2M_2 y} + B_4 e^{(M_6+M_{10})y} + B_5 e^{(M_1+M_6)}y + B_6 e^{(M_2+M_{10})}y \tag{41}$$

$$T_{11} = A_{20}e^{M_{16}y} + C_1 e^{(M_{10}+M_{12})y} + C_2 e^{(M_8+M_{10})y} + C_3 e^{(M_4+M_{10})y} + C_4 e^{(M_6+M_{12})y} + C_5 e^{(M_6+M_8)y} + C_6 e^{(M_4+M_6)y} + C_7 e^{(M_2+M_{12})y} + C_8 e^{(M_2+M_8)y} + C_9 e^{(M_2+M_4)y} \tag{42}$$

$$u_{01} = A_{22}e^{M_{18}y} + D_1e^{M_{14}y} + D_2e^{2M_{10}y} + D_3e^{2M_2y} + D_4e^{(M_6+M_{10})y} + D_5e^{(M_2+M_6)y} + D_6e^{(M_2+M_{10})y} + D_7e^{2M_6y} \quad (43)$$

$$u_{11} = A_{24}e^{M_{20}y} + E1e^{M_{16}y} + E2e^{(M_{10}+M_{12})y} + E3e^{(M_8+M_{10})y} + E4e^{(M_4+M_{10})y} + E5e^{(M_6+M_{12})y} + E6e^{(M_6+M_8)y} + E7e^{(M_4+M_6)y} + E8e^{(M_2+M_{12})y} + E9e^{(M_2+M_8)y} + E10e^{(M_2+M_4)y} \quad (44)$$

Substituting the values of C_0 and C_1 from equations(21) and (22) in equation(13) the solution for concentration distribution of the flow field is given by

$$C = e^{M_2y} + \epsilon e^{i\omega t+M_4y} \quad (45)$$

3.1 Skin friction: The wall shear stress i.e. the skin friction at the wall is given by

$$\tau_w = \left(\frac{\partial u}{\partial y}\right)_{y=0} = A_{10}M_{10}+A_{11}M_6+A_{12}M_2+Ec(A_{22}M_{10}+D_1M_6+2D_2M_{10}+2D_3M_2+(M_6+M_{10})D_4+(M_6+M_2)D_5+(M_{10}+M_2)D_6+2M_6D_7)+\epsilon Exp[I\omega t](A_{14}M_{12}+A_{18}M_{87}+A_{16}M_4+ \epsilon Exp[I\omega t]Ec\left(A_{24}M_{12}+E1M_8+E2(M_{10}+M_{12})+E3(M_{10}+M_8)+E4(M_4+M_6)+E5(M_6+M_{12})+E6(M_8+M_6)+E7(M_6+M_4)+E8(M_2+M_{12})+E9(M_2+M_8)+E10(M_2+M_4)\right)$$

3.2 Heat flux: The rate of heat transfer i.e heat flux at the wall in terms of Nusselt Number N_u is given by

$$N_u = \left(\frac{\partial T}{\partial y}\right)_{y=0} = M_6 + Ec(A_{18}M_6 + 2B_1M_{10} + 2B_2M_6 + 2B_3M_2 + B_4(M_6+M_{10}) + B_5(M_6+M_2) + B_6(M_2+M_{10})) + \epsilon Exp[I\omega t](M_8Ec(A_{20}M_8 + C_1(M_{10}+M_{12}) + C_2(M_{10}+M_8) + C_3(M_4+M_{10}) + C_4(M_6+M_{12}) + C_5(M_6+M_8) + C_6(M_6+M_4) + C_7(M_2+M_{12}) + C_8(M_2+M_8) + C_9(M_2+M_4)))$$

3.3 Mass flux: The rate of Mass transfer i.e. mass flux at the wall in terms of Sherwood Number S_h is given by

$$S_h = \left(\frac{\partial C}{\partial y}\right)_{y=0} = M_2e^{M_2y} + i\omega t + M_4\,\epsilon e^{i\omega t+M_4y}$$

4.RESULTS AND DISCUSSIONS

Hall and Radiation effects on MHD Free Convective and Mass Transfer on on unsteady flow of a viscous incompressible fluid past an infinite vertical porous plate embedded in a porous medium with heat source has been studied. The effects of parameters in the fluid flow are thoroughly analyzed and given in the form of graph to easily understand. The figure 1-5 shown velocity profile, 6 to 9 shown temperature profile and 10 and 11 shown concentration profile.

Velocity field: The flow parameters affecting the velocity flow field are permeability parameter Kp., Grashof number for heat transfer Gr, accelerate affects on the transient velocity of the flow field while Increasing effects of Grahsof number Gr, Grahsof number Gc permeability parameter Kp as shown in the figures 1,2 & 5 as well as inverse effects exists in the transient velocity of the flow field while increasing Radiation Parameter and Heat Source (S) (i.e shows decrease effects the velocity of the flow field .

Temperature Field:- Temperature profiles of the flow field with the effected parameters like Prandtl number, and Radiation Parameter are graphically shown its effects on the flow field. In the figure 6,7 indicates temperature profile goes on decrease while growing parameter Prandtl Number (Pr) and Radiation Parameter .As well as figure 8 shown the increasing effects of temperature profile while growing parameter of Heat Source (S) and Grahsof number (Gr)

Concentration Field: Schmidt Number(Sc) and Chemical reaction parameter plays important role in the concentration fluid flow field. The effects of these parameters on the fluid flow field graphically shown. While growing Schmidt number (Sc) decrease the concentration boundary layer thickness of the flow in similar way the effects of mass transfer are decrease while growing of Chemical reaction parameter as shown in the figure 10 and figure 11.

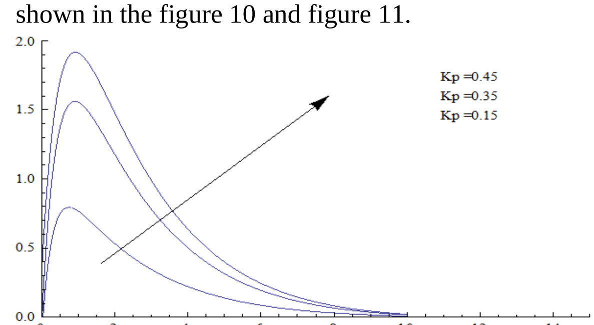

Fig.1Transient Velocity for various values of Kp

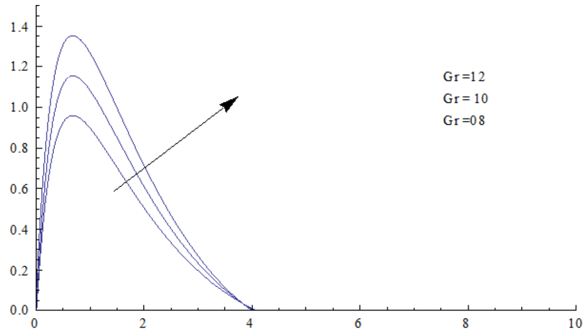

Fig.2 Transient Velocity for various values of Gr

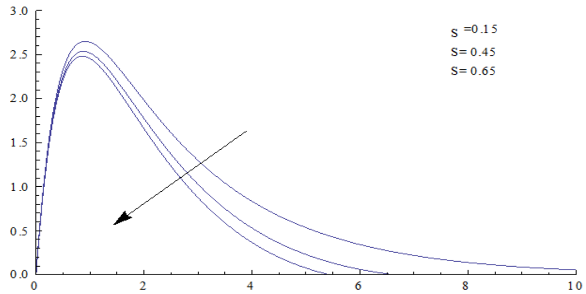

Fig.3 Transient Velocity for various values of S

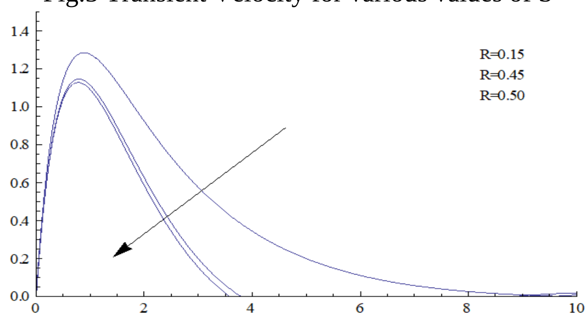

Fig.4 Transient Velocity for various values of R

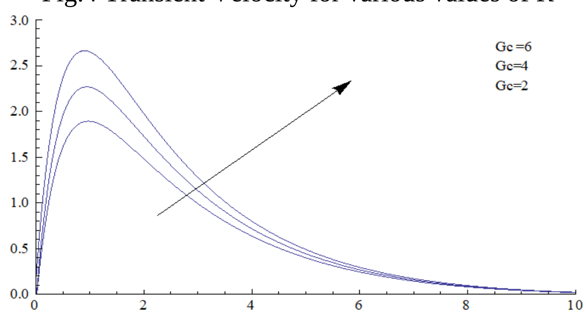

Fig.5 Transient Velocity for various values of Gc

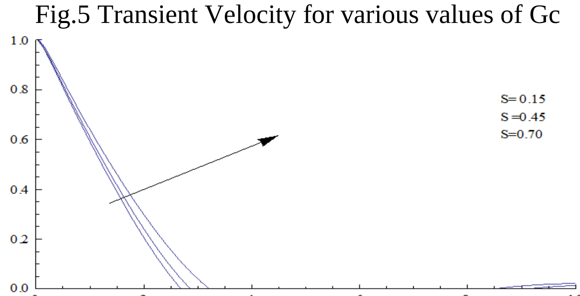

Fig.6 Temperature Profile for various values of S

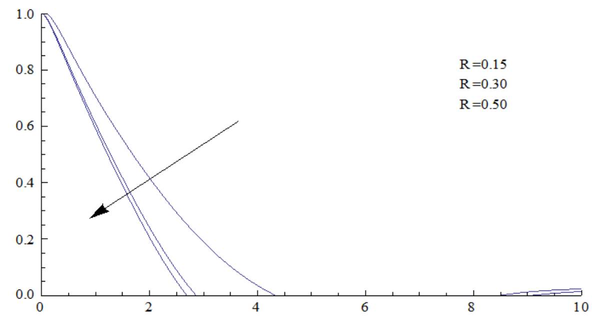

Fig.7 Temperature Profile for various values of R

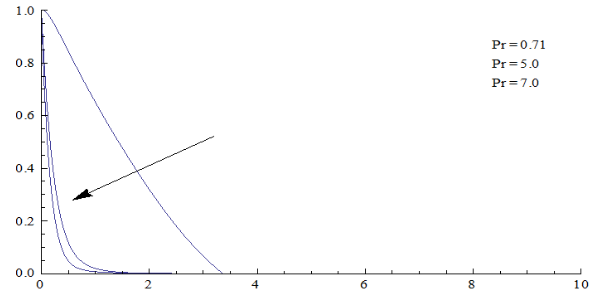

Fig.8 Temperature Profile for various values of Pr

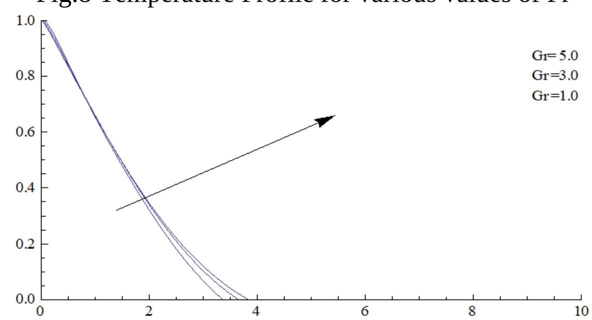

Fig.9 Temperature Profile for various values of Gr

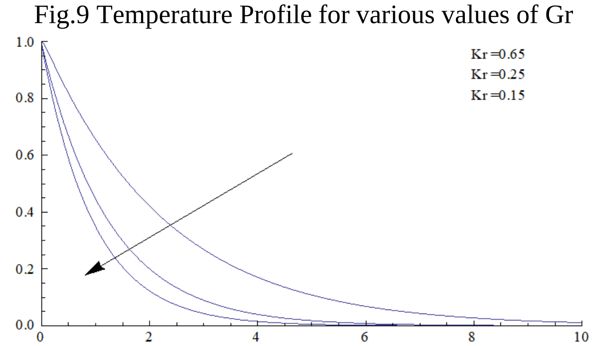

Fig.10 Concentration Profile for various values of Kr

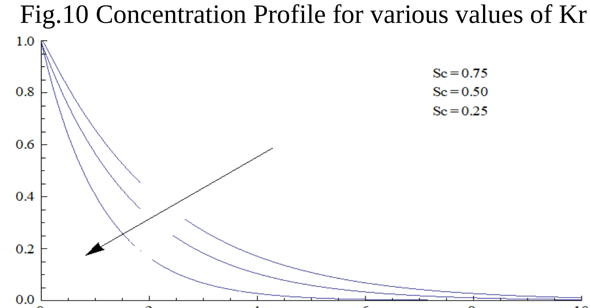

Fig.11 Concentration Profile for various values of Sc

Table 1. Variation in the value of skin friction at wall against Pr for different values of M,m with Gr=2,Gc=2,S=0.1,Sc=0.66,Ec=0.002,

M	m	R	Pr =0.71	Pr=5	Pr=7
1	1	0.65	1.6306	1.2120	1.0498
2	3	0.45	1.6771	1.1582	1.0587
3	5	0.25	1.7036	1.1454	1.0580
4	10	0.15	1.7210	1.1433	1.0594

Table 2. Variation in the value of heat flux at wall against Pr for different values of M,m with Gr=2,Gc=2,S=0.1,Sc=0.66,Ec=0.002

M	m	R	Pr =0.71	Pr=7	Pr=10
1	1	0.15	0.1813	-6.200	-9.132
2	3	0.45	-0.4637	-5.750	-8.699
3	5	0.65	-0.5565	-5.373	-8.353
4	10	0.75	-0.5832	-5.137	-8.144

Table 3. Variation in the value of Mass flux at wall against for different values of Kr, Sc

Kr	Sc=1.0	Sc=2.0	Sc=3.0
0.1	-1.0856	-2.0886	-3.0896
0.5	-1.3616	-2.4087	-3.4304
1.0	-1.6145	-2.7275	-3.7861

5.CONCLUSION

In this paper clearly shows effects of the parameters in the flow fluid. The velocity, temperature and concentration profiles are shown graphically with various values of parameters.

- Permeability parameter(Kp) accelerates the transient velocity of the fluid flow.
- Growing of Grashof Number (Gr) and Grashof Number (Gc) accelerates the transient velocity of the fluid flow but growing Radiation Parameter (R) and Heat Source (S) retards the transient velocity.
- Growing of Heat Source (S) accelerates the temperature but the reverse process if Prandtl Number (Pr) and Radiation Parameter (R) retards the Temperature of the fluid flow.
- Grashof Number (Gr) accelerates the Temperature profile of the fluid flow.
- Chemical Reaction Parameter and Schmidt Number (Sc) are retards Concentration of Mass while both are grown.
- The variation of skin friction at the wall against the different values of Magnetic field parameter and Hall Parameter are entered in Table.1.It observed decrease effects exists if the prandtl number (Pr=5)
- The rate of heat transfer at the wall for the different values Magnetic field Parameter and Hall Parameter are entered in Table.2. It is noted that decreasing effects of heat transfer while Prandtl Number (Pr=0.71)
- While the rate of mass transfer at the wall decrease while increase effects of Schmidt Number and increase of Chemical reaction parameter

Appendix:-

$$B_3 = \frac{-PrM_2{}^2 A_{12}{}^2}{4M_2{}^2 + 2PrM_2 + \frac{Pr}{4}(s+4R)}$$

$$B_4 = \frac{-2PrM_{10}A_{10}M_6A_{11}}{(M_6+M_{10})^2 + Pr(M_6+M_{10}) + \frac{Pr}{4}(s+4R)}$$

$$B_5 = \frac{-2PrM_2A_{12}M_6A_{11}}{(M_6+M_2)^2 + Pr(M_6+M_2) + \frac{Pr}{4}(s+4R)}$$

$$B_6 = \frac{-2PrM_2A_{10}M_{10}A_{12}}{(M_{10}+M_2)^2 + Pr(M_{10}+M_2) + \frac{Pr}{4}(s+4R)}$$

$$A_{20} = -(C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9)$$

$$C_1 = \frac{-2PrM_{12}A_{10}M_{10}A_{14}}{(M_{10}+M_{12})^2 + Pr(M_{10}+M_{12}) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_2 = \frac{-2PrM_8A_{10}M_{10}A_{15}}{(M_{10}+M_8)^2 + Pr(M_{10}+M_8) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_3 = \frac{-2PrM_4A_{10}M_{10}A_{16}}{(M_{10}+M_4)^2 + Pr(M_{10}+M_4) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_4 = \frac{-2PrM_6A_{11}M_{12}A_{14}}{(M_6+M_{12})^2 + Pr(M_6+M_{12}) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_5 = \frac{-2PrM_6A_{11}M_8A_{15}}{(M_6+M_8)^2 + Pr(M_6+M_8) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_6 = \frac{-2PrM_6A_{11}M_4A_{16}}{(M_6+M_4)^2 + Pr(M_6+M_4) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_7 = \frac{-2PrM_2A_{12}M_{12}A_{14}}{(M_2+M_{12})^2 + Pr(M_2+M_{12}) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_8 = \frac{-2PrM_2A_{12}M_8A_{15}}{(M_2+M_8)^2 + Pr(M_2+M_8) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$C_9 = \frac{-2PrM_2A_{12}M_4A_{16}}{(M_2+M_4)^2 + Pr(M_2+M_4) - \frac{Pr}{4}(i\omega - (s+4R))}$$

$$A_{22} = -(D_1 + D_2 + D_3 + D_4 + D_5 + D_6 + D_7)$$

$$D_1 = \frac{-GrA_{18}}{{M_6}^2 + M_6 - M_1}$$

$$D_2 = \frac{-GrB_1}{4{M_{10}}^2 + 2M_{10} - M_1}$$

$$D_3 = \frac{-GrB_2}{4{M_6}^2 + 2M_6 - M_1}$$

$$D_4 = \frac{-GrB_3}{4{M_2}^2 + M_2 - M_1}$$

$$D_5 = \frac{-GrB_4}{(M_6+M_{10})^2 + (M_6+M_{10}) - M_1}$$

$$D_6 = \frac{-GrB_5}{(M_6+M_2)^2 + (M_6+M_2) - M_1}$$

$$D_7 = \frac{-GrB_6}{(M_{10}+M_2)^2 + (M_{10}+M_2) - M_1}$$

$$A_{24} = -(E_1 + E_2 + E_3 + E_4 + E_5 + E_6 + E_7 + E_8 + E_9 + E_{10})$$

$$E1 = \frac{-GrA_{20}}{{M_8}^2 + M_8 - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E2 = \frac{-GrC_1}{(M_{10}+M_{12})^2 + (M_{10}+M_{12}) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E3 = \frac{-GrC_2}{(M_{10}+M_8)^2 + (M_{10}+M_8) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E4 = \frac{-GrC_3}{(M_{10}+M_4)^2 + (M_{10}+M_4) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E5 = \frac{-GrC_4}{(M_{12}+M_6)^2 + (M_{12}+M_6) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E6 = \frac{-GrC_5}{(M_{6+}M_8)^2 + (M_{6+}M_8) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E7 = \frac{-GrC_6}{(M_{4+}M_6)^2 + (M_{4+}M_6) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E8 = \frac{-GrC_7}{(M_{12+}M_2)^2 + (M_{12+}M_2) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E9 = \frac{-GrC_8}{(M_{2+}M_8)^2 + (M_{2+}M_8) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

$$E10 = \frac{-GrC_9}{(M_{2+}M_4)^2 + (M_{2+}M_4) - \left(\frac{1}{Kp} + \frac{i\omega}{4} + 4M_1\right)}$$

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