Chemical Reaction Effects on Heat and Mass Transfer of Unsteady Flow over an Infinite Vertical Porous Plate Embedded in a Porous Medium with Heat Source

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Abstract:- The work reported herein estimates the effects of Chemical reaction 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. It is interesting to note that an increase of Grashof number,Permeability parameter and Chemical reaction parameter for heat transfer accelerates the transient velocity of fluid.Further, it is observed that the temperature profile of the fluid flow decrease while increasing of prandtl number.But increase of permeability parameter shows the reverse process.The effect of increasing Schmidt number is to decrease the concentration boundary layer thickness of the flow field.Further, a growing permeability parameter increasing the skin friction at the wall and growing of permeability parameter ($Kp \leq 1$) leads to increase the magnitude of the rate of heat transfer at the wall.While Chemical reaction parameter 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, Chemical effects, permeability parameter, Grashof Number, Prandtl number, Skin friction.

1. Introduction

The phenomenon of hydrodynamics flow with heat and mass transfer past a porous plate embedded in a porous medium has attracted the attention of a good number of investigators because of its varied applications in many engineering problems such as plasma studies, geothermal energy extractions and in the boundary layer control in the field of aerodynamics. The Chemical reaction plays a important role in numerous industrial applications such as polymer production, manufacturing of ceramics' and food processing, evaporation at the surface of a water body, Generation of electricity is one in which electrical energy is extracted from the moving conducting fluid with chemical reaction plays important role in power industry. Several investigators reported such flows by involving various physical situations. Gersten K., Gross J.F. [1] discuss the nature of Flow and heat transfer along a plane wall with periodic suction. Yamamoto K.m Iwamura N[2] are studied the flow with convective acceleration through a porous medium. Bejan A and Khair K.R.[3] are deeply discussed the effects of Heat and mass transfer by natural convection in a porous medium. W.L.Cooper., V.W.Nee[4] were studied the Fluid Mechanics of oscillatory and modulated flows and associated applications in heat and mass transfer. Rapits A.A.[5] is studied the Flow through a porous medium in the presence of magnetic field. Balamurugan K.S., Varma S.V.K.,Ramakrishanaprasad K[6] deeply analyzsed the Thermo diffusion and chemical reaction effects on a three dimensional MHD Mixed convective flow along an infinite vertical porous plate with viscous and Joules dissipation.. C.Ceindreau and J.L. Auriault[7] analysed the Effect of Magnetic field on flow through porous medium. J. Prakash and A.Ogulu[8] were studied the Unsteady two dimensional flow of a radiating and chemically reacting MHD fluid wih time dependent suction Ling S.C. Nazar R., Pop.I[9] are studied the Steady mixed convection boundary layer flow over a vertical flat surface in a porous medium filled with water at 4 degree variable surface. R.Muthucumarasamy [10] is deeply discussed the Effects of heat and mass transfer on flow past an oscillatory vertical plate with variable temperature. R.Muthucumarasamy and B.Janakiraman [11] are studied the Mass transfer effects on isothermal vertical oscillating plate in the presence of chemical reaction. M.C.Raju,S.V.K. Verma, P.V.Reddy and S.Saha[12] analyzed the Soret Effect due to Natural convection between heated inclined plates with magnetic field. Balamuguran K.S., Varma S.V.K. and Iyengar N.ch.S.N [13] discussed the nature of the Chemcial reaction and thermo diffusion effects on MHD three dimensional free convection coquette flow with Heat Absorpton. N.Senapati and R.K.Dhal [14] discussed the nature of the Magnetic effect on mass and heat transfer of hydrodynamic flow past a vertical oscillating plate in the presence of chemical reaction.S.S. Das (et.al) [15] discussed the combined natural convection and mass transfer effects on unsteady flow past an infinite vertical

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porous plate embedded in a porous medium with heat source.

2. Formulation of the Problem

Considered a unsteady natural convective heat 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:

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

Momentum Equation:

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

Energy Equation:

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

Concentration Equation:

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

Boundary Conditions of the problem are:

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

$$u' \to 0, T' \to T_\infty', C' \to C_\infty' \;\; as\; y' \to \infty \qquad (5)$$

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

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

$$Gr = \frac{\vartheta g\beta(T'_w - T_\infty')}{v'^3_0},\; Gc = \frac{\vartheta g\beta(T'_w - T_\infty')}{v'^3_0}, Sc = \frac{\vartheta}{D}, S = \frac{4S'\vartheta}{v'^2_0}, Ec = \frac{v'^2_0}{Cp(T'_w - T_\infty')}, K_r = \frac{K_r'\vartheta}{\vartheta_0^2} \qquad (6)$$

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

$$\frac{1}{4}\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + GrT + Gc - \frac{1}{Kp}u \qquad (7)$$

$$\frac{1}{4}\frac{\partial T}{\partial t} - \frac{\partial T}{\partial y} = \frac{1}{Pr}\frac{\partial^2 T}{\partial y^2} + \frac{1}{4}ST + Ec\left(\frac{\partial u}{\partial y}\right)^2 \qquad (8)$$

$$\frac{1}{4}\frac{\partial C}{\partial t}-\frac{\partial C}{\partial y}=\frac{1}{Sc}\frac{\partial^2 C}{\partial y^2}-Krc \tag{9}$$

The Corresponding boundary conditions are:

$$u=0, T=1+\varepsilon e^{i\omega t}, C=1+\varepsilon e^{i\omega t} \;\; at \;\; y=0$$

$$u\to 0, T\to 0, C\to 0 \;\; as\; y\;\to\infty \tag{10}$$

3**. Method of Solution**

To solve equations (7), (8) and (9) , Assuming ε to be small so that one can express u, T and Cas a regular perturbation series interms ε as in the neighborhood of the plate as

$$u(y,t)=u_0(y)+\varepsilon e^{i\omega t}u_1(y)+O(\varepsilon^2) \tag{11}$$

$$T(y,t)=T_0(y)+\varepsilon e^{i\omega t}T_1(y)+O(\varepsilon^2) \tag{12}$$

$$C(y,t)=C_0(y)+\varepsilon e^{i\omega t}C_1(y) \tag{13}$$

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

$$u_0''+u_0'-\frac{1}{Kp}u_0=-GrT_0-GcC_0 \tag{14}$$

$$T_0''+PrT_0'+\frac{PrS}{4}T_0=-PrEc\left(\frac{\partial u_0}{\partial y}\right)^2 \tag{15}$$

$$C_0''+ScC_0'-ScK_rC_0=0 \tag{16}$$

First Order:

$$u_1''+u_1'-\left(\frac{i\omega}{4}+\frac{1}{Kp}\right)u_1=-GrT_1-GcC_1 \tag{17}$$

$$T_1''+PrT_1'-\frac{Pr}{4}(i\omega-S)T_1=-2PrEc\left(\frac{\partial u_0}{\partial y}\right)\left(\frac{\partial u_1}{\partial y}\right) \tag{18}$$

$$C_1''+ScC_1'-Sc\left(\frac{i\omega}{4}+K_r\right)C_1=0 \tag{19}$$

The Corresponding boundary conditions are

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

$$y\to\infty: u_0=0, T_0=0, C_0=0, u_1=0, T_1=0, C_1=0 \tag{20}$$

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

$$C_0=e^{M_2y} \tag{21}$$

$$C_1=e^{M_4y} \tag{22}$$

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

$$u_0(y)=u_{00}(y)+Ecu_{01} \tag{23}$$

$$T_0=T_{00}+EcT_{01} \tag{24}$$

$$u_1=u_{10}+Ecu_{11} \tag{25}$$

$$T_1 = T_{10} + EcT_{11} \quad (26)$$

Now using equations (23) –(26) in equations (14),(15),(17) and (18) and equating the coefficients of like powers of Ec neglecting of Ec^2, we get the following set of differential equations

Zeroth Order:

$$u_{00}'' + u_{00}' - \left(\frac{1}{Kp}\right)u_{00} = -GrT_{00} - GcC_0 \quad (27)$$

$$u_{10}'' + u_{10}' - \left(\frac{i\omega}{4} + \frac{1}{Kp}\right)u_{10} = -GrT_{10} - GcC_1 \quad (28)$$

$$T_{00}'' + PrT_{00}' + \frac{PrS}{4}T_{00} = 0 \quad (29)$$

$$T_{10}'' + PrT_{10}' - \frac{Pr}{4}(i\omega - S)T_{10} = 0 \quad (30)$$

The Corresponding boundary conditions are

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

$$y \to \infty: u_{00} = 0, T_{00} = 0, U_{10} = 0, T_{10} = 1 \quad (31)$$

First Order:

$$u_{01}'' + u_{01}' - \left(\frac{1}{Kp}\right)u_{01} = -GrT_{01} \quad (32)$$

$$u_{11}'' + u_{11}' - \left(\frac{i\omega}{4} + \frac{1}{Kp}\right)u_{11} = -GrT_{11} \quad (33)$$

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

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

The Corresponding boundary conditions become,

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

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

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

$$u_{00} = A_{10}e^{M_{10}y} + A_{11}e^{M_6y} + A_{12}e^{M_2y} \quad (37)$$

$$T_{00} = e^{M_6y} \quad (38)$$

$$u_{10} = A_{14}e^{M_{12}y} + A_{15}e^{M_8y} + A_{16}e^{M_4y} \quad (39)$$

$$T_{10} = e^{M_8y} \quad (40)$$

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

$$T_{01} = A_{18}e^{M_{14}y} + B_1e^{2M_{10}y} + B_2e^{2M_6y} + B_3e^{2M_2y} + B_4e^{(M_6+M_{10})y} + B_5e^{(M_1+M_6)}y + B_6e^{(M_2+M_{10})}y \quad (41)$$

$$T_{11} = A_{20}e^{M_{16}y} + C_1e^{(M_{10}+M_{12})y} + C_2e^{(M_8+M_{10})y} + C_3e^{(M_4+M_{10})y} + C_4e^{(M_6+M_{12})y} + C_5e^{(M_6+M_8)y} + C_6e^{(M_4+M_6)y} + C_7e^{(M_2+M_{12})y} + C_8e^{(M_2+M_8)y} + C_9e^{(M_2+M_4)y} \quad (42)$$

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

$$u_{11} = A_{24}e^{M_{20}y} + E_1e^{M_{16}y} + E_2e^{(M_{10}+M_{12})y} + E_3e^{(M_8+M_{10})y} + E_4e^{(M_4+M_{10})y} + E_5e^{(M_6+M_{12})y} + E_6e^{(M_6+M_8)y} + E_7e^{(M_4+M_6)y} + E_8e^{(M_2+M_{12})y} + E_9e^{(M_2+M_8)y} + E_{10}e^{(M_2+M_4)y} \quad (44)$$

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

$$\tau_w = \left(\frac{\partial u}{\partial y}\right)_{y=0} = A_{10}M_{10}+A_{11}M_6+A_{12}M_2+Ec(A_{22}M_{10}+D_1M_6+2D_2M_{10}+2D_3M_2+(M_6+M_{10})D_4+(M_6+M_2)D_5+(M_{10}+M_2)D_6+2M_6D_7)+\epsilon Exp[I\omega t](A_{14}M_{12}+A_{18}M_{87}+A_{16}M_4+ \epsilon Exp[I\omega t]Ec(A_{24}M_{12}+E_1M_8+E_2(M_{10}+M_{12})+E_3(M_{10}+M_8)+E_4(M_4+M_6)+E_5(M_6+M_{12})+E_6(M_8+M_6)+E_7(M_6+M_4)+E_8(M_2+M_{12})+E_9(M_2+M_8)+E_{10}(M_2+M_4))$$

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

$$S_h = \left(\frac{\partial c}{\partial y}\right)_{y=0} = M_2 + M_4\epsilon Exp[I\omega t]$$

4.Results and discussions:-

The effects of Chemical reaction parameter in heat and mass transfer 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, 6,7 & 8 shown temperature profile and 9 and 10 shown concentration profile.

Velocity field: The flow parameters affecting the velocity flow field are permeability parameter Kp., Grashof number for both heat and mass transfer Gr, Gc, Schmidt Number Sc, Chemical reaction parameter K_r and Heat source parameter s the accelerate affects on the transient velocity of the flow field while Increasing effects of Grahsof number Gr, Grahsof number Gc, as shown in the figures 1,2 as well as inverse effects exists in the transient velocity of the flow field while increasing Chemical Parameter(K_r)(i.e shows decrease effects the velocity of the flow field in the figure .3). But increasing of Permeability parameter Kp and Heat source S accelerate the transient velocity of the fluid flow as shown in the figure 4 and 5.

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

Concentration Field: Schmidt Number 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 (Kr)as shown in the

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figure 9 and figure 10.

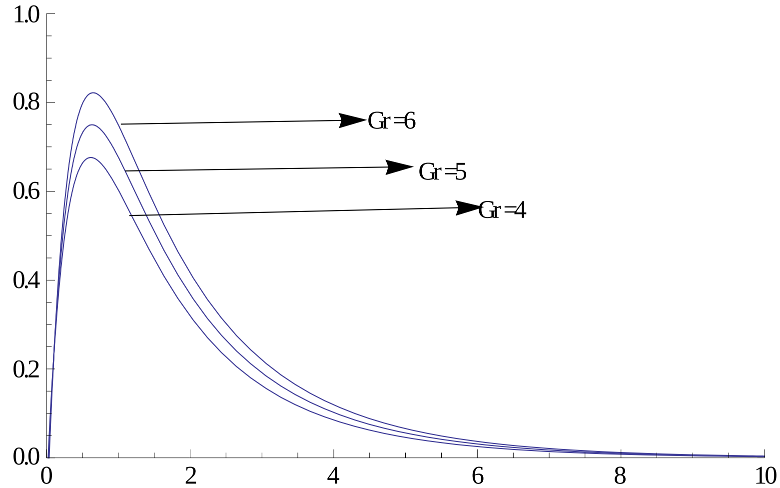

Fig.1 Transient Velocity for various values of Gr

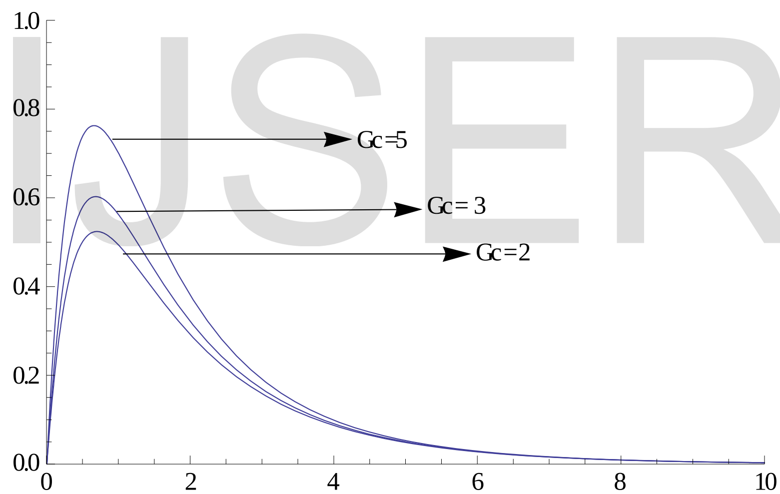

Fig.2 Transient Velocity for various values of Gc

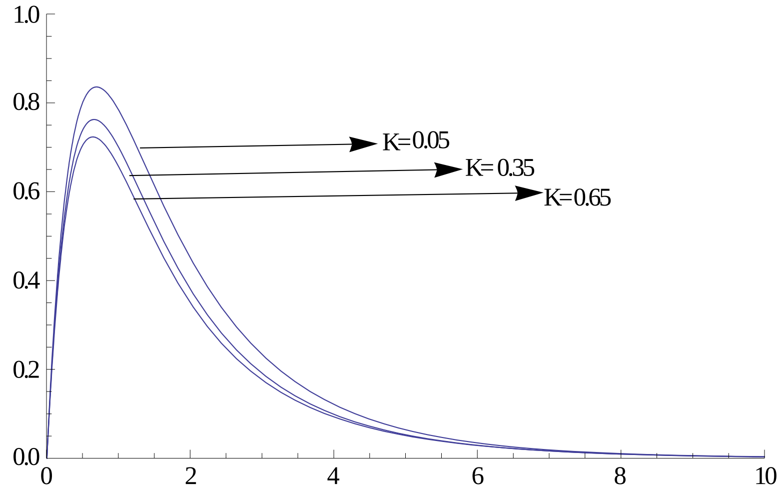

Fig.3 Transient Velocity for various values of K

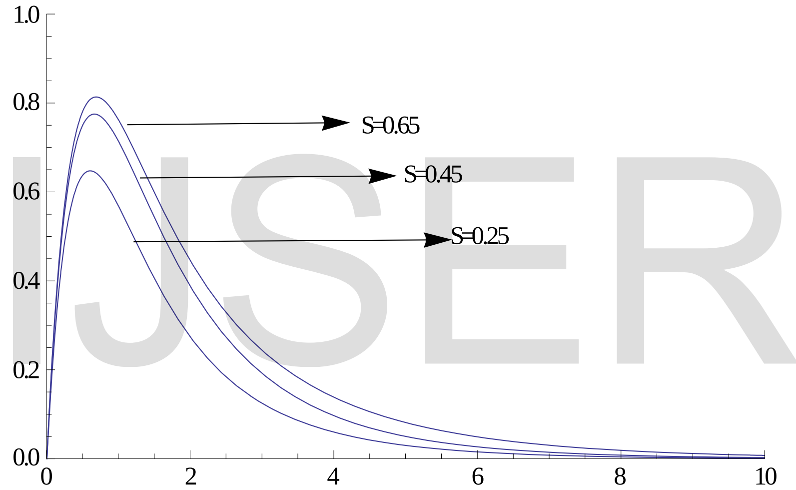

Fig.4 Transient Velocity for various values of S

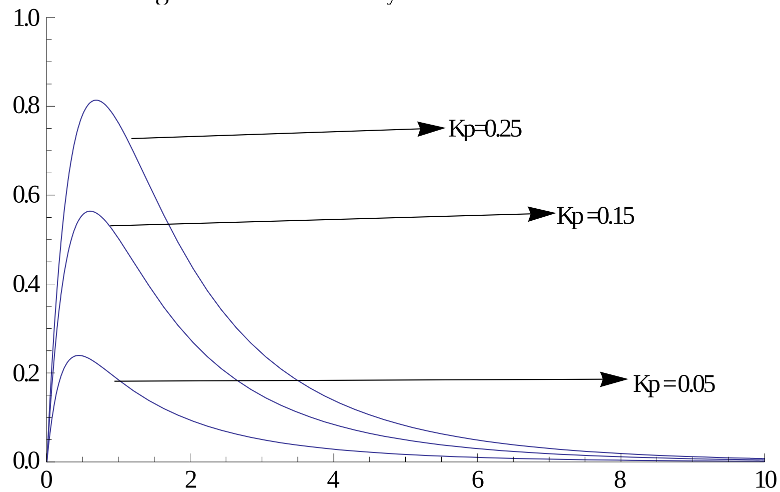

Fig.5 Transient Velocity for various values of Kp

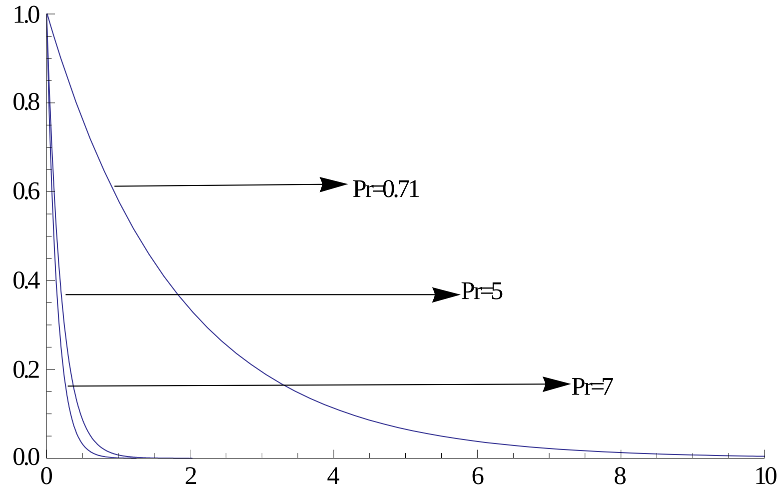

Fig.6 Temperature Distribution for various values of Pr

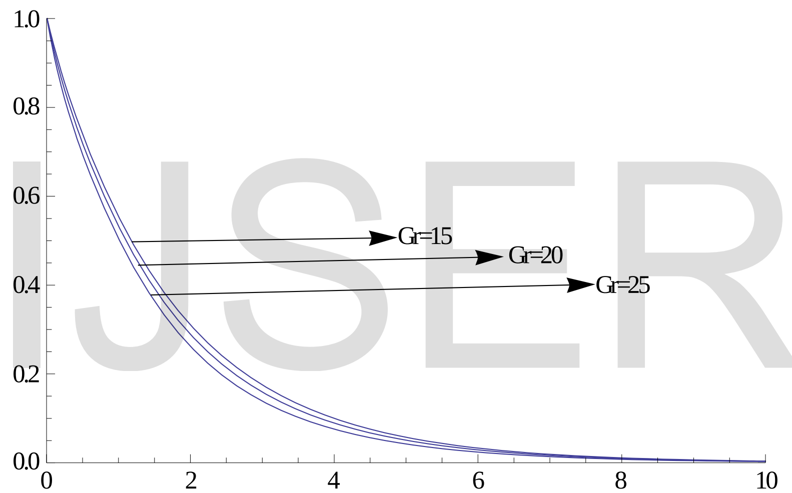

Fig.7 Temperature Distribution for various values of Gr

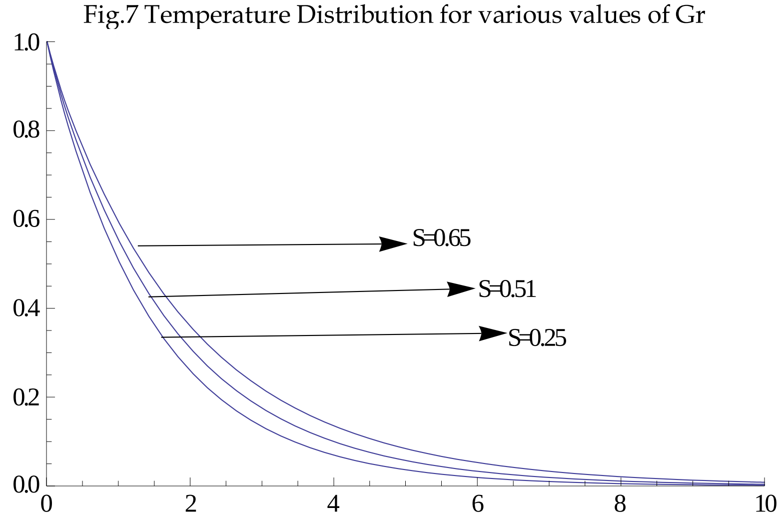

Fig.8 Temperature Distribution for various values of S

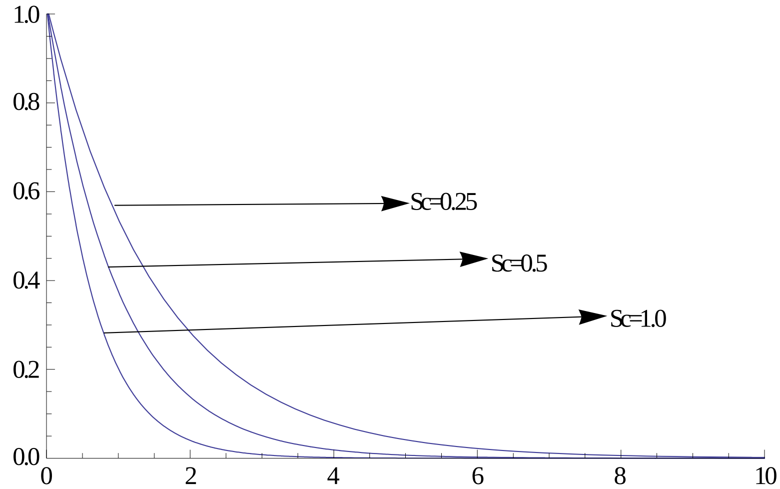

Fig.9 Concentration Distribution for various values of Sc

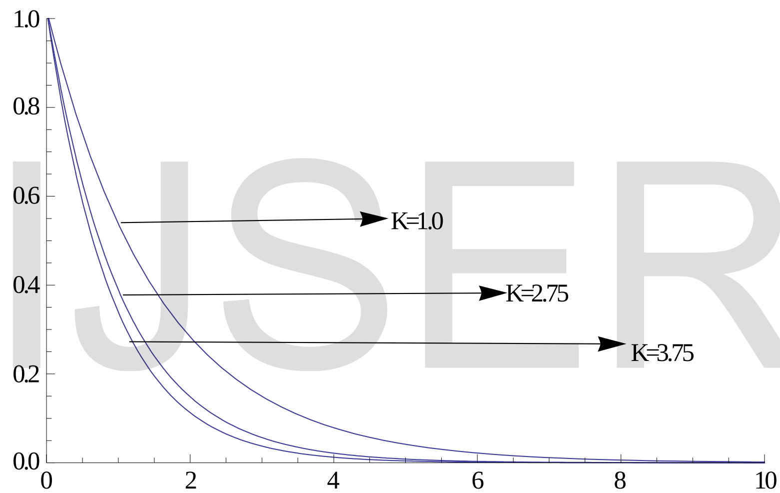

Fig.10 Concentration Distribution for various values of Kr

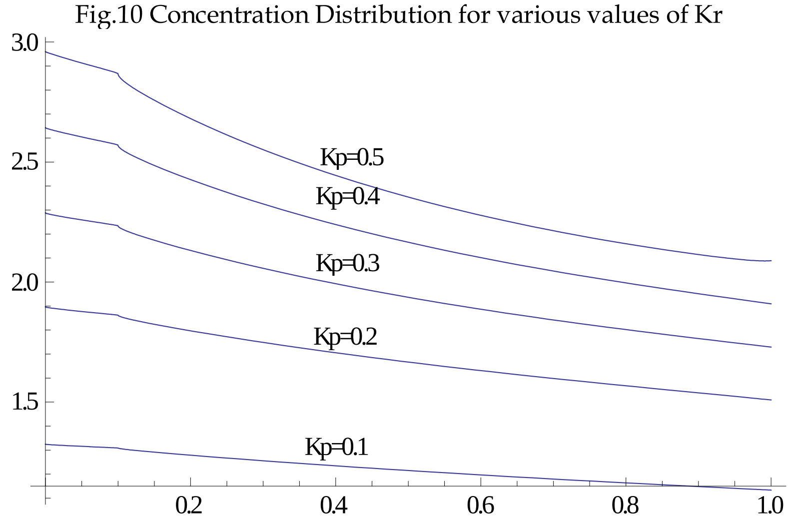

Fig.11 Skin friction for various values of Kp

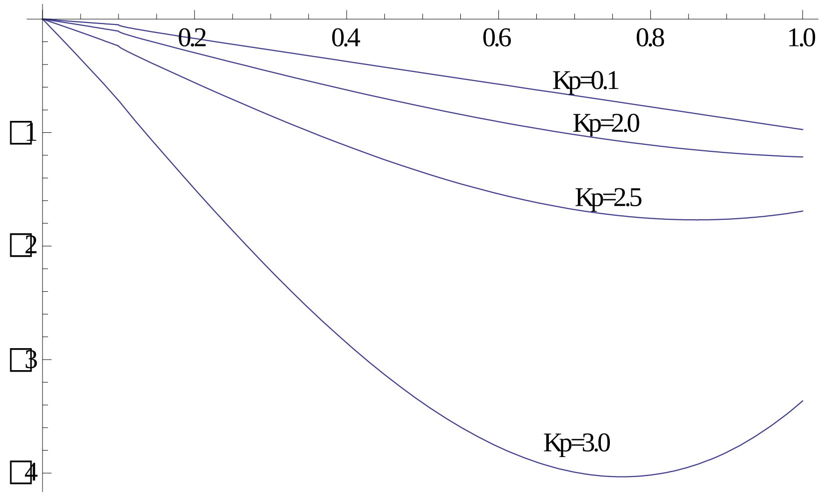

Fig.12 Heat Flux against various values of Kp

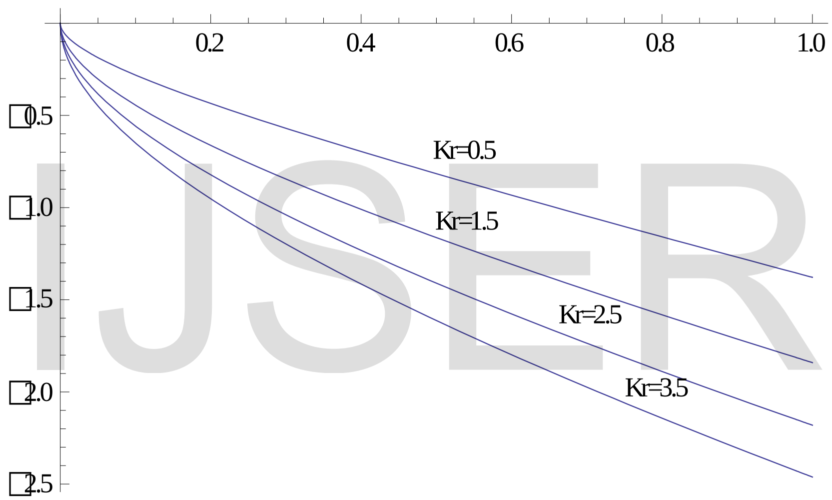

Fig.13 Mass Flux for various values of Kr

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 for the small values of (Kp<1) but growing values of Kp shows the reverse effects.

Growing of Grashof Number (Gr) accelerates the transient velocity of the fluid flow but growing Chemical reaction parameter(Kr) retards the transient velocity.Permeability parameter (Kp) accelerates the temperature profile of the fluid flow, but the reverse process exists if the growing parameter of Prandtl number.

The parameter of Chemical reaction (K_r) retards the concentration of mass while grown.The same effects exists in the concentration of mass while increasing of Schmidt Number(S_c)

The variation of skin friction at the wall against the different values of permeability parameter (Kp) and Prandtl number (Pr) are shown in Fig.11.It observed the growing permeability parameter and Prandtl number shows increasing effects of skin friction.

The rate of heat transfer at the wall for the different values of Prandtl number (Pr) and permeability parameter (Kp) are shown in Fig.12. It is noted that the enchance of heat transfer while increasing effects of heat transfer for Prandtl number and ($Kp \leq 1$) but the reverse process of heat transfer exists while ($K_p > 1$)

While the rate of mass transfer at the wall decrease when increasing values of Schmidt Number (S_c) and Chemical reaction parameter (Kr)

Appendix:-

$$M_2 = \frac{-Sc - \sqrt{Sc^2 + 4ScK_r}}{2}$$

$$M_4 = \frac{-Sc - \sqrt{Sc^2 + Sc(4K_r + i\omega)}}{2}$$

$$M_6 = \frac{-Pr - \sqrt{Pr^2 - Prs}}{2}$$

$$M_8 = \frac{-Pr - \sqrt{Pr^2 + \mathrm{Pr}(i\omega - s)}}{2}$$

$$M_{10} \frac{= -1 - \sqrt{1 + \frac{4}{Kp}}}{2}$$

$$M_{12} = \frac{-1 - \sqrt{1 + \frac{4}{Kp} + i\omega}}{2}$$

$$A_5 + A_6 = 1\,,$$

$$A_{11} = \frac{-Gr}{{M_6}^2 + M_6 - \frac{1}{Kp}}$$

$$A_{12} = \frac{-Gc}{{M_2}^2 + M_2 - \frac{1}{Kp}}$$

$$A_{10} = -(A_{11} + A_{12})$$

$$A_{15} = \frac{-Gr}{{M_8}^2 + M_8 - (\frac{1}{Kp} + \frac{i\omega}{4})}$$

$$A_{16} = \frac{-Gc}{{M_4}^2 + M_4 - (\frac{1}{Kp} + \frac{i\omega}{4})}$$

$$A_{14} = -(A_{15} + A_{16})$$

$$A_{18} = -(B_1 + B_2 + B_3 + B_4 + B_5 + B_6)$$

$$B_1 = \frac{-Pr{M_{10}}^2 {A_{10}}^2}{4{M_{10}}^2 + 2PrM_{10} + \frac{Prs}{4}}$$

$$B_2 = \frac{-PrM_6{}^2 A_{11}{}^2}{4M_6{}^2 + 2PrM_6 + \frac{Prs}{4}}$$

$$B_3 = \frac{-PrM_2{}^2 A_{12}{}^2}{4M_2{}^2 + 2PrM_2 + \frac{Prs}{4}}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$D_1 = \frac{-GrA_{18}}{{M_6}^2 + M_6 - \frac{1}{Kp}}$$

$$D_2 = \frac{-GrB_1}{4{M_{10}}^2 + 2M_{10} - \frac{1}{Kp}}$$

$$D_3 = \frac{-GrB_2}{4{M_6}^2 + 2M_6 - \frac{1}{Kp}}$$

$$D_4 = \frac{-GrB_3}{4{M_2}^2 + M_2 - \frac{1}{Kp}}$$

$$D_5 = \frac{-GrB_4}{(M_6+M_{10})^2 + (M_6+M_{10}) - \frac{1}{Kp}}$$

$$D_6 = \frac{-GrB_5}{(M_6+M_2)^2 + (M_6+M_2) - \frac{1}{Kp}}$$

$$D_7 = \frac{-GrB_6}{(M_{10}+M_2)^2 + (M_{10}+M_2) - \frac{1}{Kp}}$$

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

$$E_1 = \frac{-GrA_{20}}{{M_8}^2 + M_8 - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_2 = \frac{-GrC_1}{(M_{10}+M_{12})^2 + (M_{10}+M_{12}) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

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

$$E_4 = \frac{-GrC_3}{(M_{10}+M_4)^2 + (M_{10}+M_4) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_5 = \frac{-GrC_4}{(M_{12+}M_6)^2 + (M_{12+}M_6) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_6 = \frac{-GrC_5}{(M_{6+}M_8)^2 + (M_{6+}M_8) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_7 = \frac{-GrC_6}{(M_{4+}M_6)^2 + (M_{4+}M_6) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_8 = \frac{-GrC_7}{(M_{12+}M_2)^2 + (M_{12+}M_2) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_9 = \frac{-GrC_8}{(M_{2+}M_8)^2 + (M_{2+}M_8) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

$$E_{10} = \frac{-GrC_9}{(M_{2+}M_4)^2 + (M_{2+}M_4) - \left(\frac{1}{Kp} + \frac{i\omega}{4}\right)}$$

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Reference:

[1]Gersten K., Gross J.F. “Flow and heat transfer along a plane wall with periodic suction”.Z.Angew Math.Phys.1974,25,399-408.
[2]Yamamoto K.m Iwamura N. “Flow with convective acceleration through a porous medium”.Engineering Math.1976,10,41-54.
[3] Bejan A and Khair K.R. “Heat and mass transfer by natural convection in a porous medium”. International Journal of Heat and Mass Transfer.1985,28,909-918.
[4]W.L.Cooper., V.W.Nee. “Fluid Mechanics of oscillatory and modulated flows and associated applications in heat and mass transfer”. Journal of Energy Heat and Mass Transfer. 1993,15,1-19.
[5] Rapits A.A., “Flow through a porous medium in the presence of magnetic field”.International Journal of Energy.1986,10,97-100.
[6] Balamurugan K.S., Varma S.V.K.,Ramakrishanaprasad K. “Thermo diffusion and chemical reaction effects on a three dimensional MHD Mixed convective flow along an infinite vertical porous plate with viscous and Joules dissipation”. International Journal of Advances in Science and Technology.2001.3,73-92.
[7]C.Ceindreau and J.L. Auriault. “Effect of Magnetic field on flow through porous medium”.Journal of Fluid Mech. 2002,466,343-363.
[8] J. Prakash and A.Ogulu. “Unsteady two dimensional flow of a radiating and chemically reacting MHD fluid wih time dependent suction”. Indian Journal of Pure and Applied Physics.2006,44,805-810.
[9] Ling S.C. Nazar R., Pop.I “Steady mixed convection boundary layer flow over a vertical flat surface in a porous medium filled with water at 4 degree variable surface heat flux”.Transport in Porous Media.2007,3,307-321.
[10]R.Muthucumarasamy. “Effects of heat and mass transfer on flow past an oscillatory vertical plate with variable temperature”. International Journal of Applied Math and Mech.2008,4,59-65.
[11]R.Muthucumarasamy and B.Janakiraman. “Mass transfer effects on isothermal vertical oscillating plate in the presence of chemical reaction”. International Journal of Applied math and Mech.2008,4,66-74
[12] M.C.Raju,S.V.K. Verma, P.V.Reddy and S.Saha.”Soret Effect due to Natural convection between heated inclined plates with magnetic field”.International Journalof Mechanical Engineering,2008,39,65-70.
[13] Balamuguran K.S., Varma S.V.K. and Iyengar N.ch.S.N. “Chemcial reaction and thermo diffusion effects on MHD three dimensional free convection coquette flow with Heat Absorpton”. International Journal of Advances in Science and Technolgoy.2011.3,58-72.
[14] N.Senapati and R.K.Dhal . “Magnetic effect on mass and heat transfer of hydrodynamic flow past a vertical oscillating plate in the presence of chemical reaction”.AMSE.2011,79,60-66.
[15] S.S. Das (et.al) “Discussed the combined natural convection and mass transfer effects on unsteady flow past an infinite vertical porous plate embedded in a porous medium with heat source”.International Journal of Energy and Environment.2012,3,591-604.

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