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HEAT AND MASS TRANSFER OF OSCILLATORY ROTATION FLUID FLOW ALONG A POROUS PLATE WITH HALL CURRENT AND TEMPERATURE VARYING COSINUSOIDALLY WITH TIME DEPENDENT IN PRESENCE OF SORET EFFECT

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Abstract:

In this Article, the effects of Hall current with rotation effects on unsteady MHD Oscillatory flow through a porous medium in the presence of Soret effect with homogeneous first order chemical reaction under the influence of uniform magnetic field is studied. The Plate is subjected to the constant injection and suction velocities respectively. 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 of fluid flow for the different values of the parameters like Hartmann number M, Grashof Number Gr, Chemical reaction parameter Kr. It is observed that increase of Hartmann number M, Grashof Number Gr and Soret effects S_0 shows the increase effects of Velocity profile. Temperature profile shows retardation while increase of Prandtl number Pr. The increase of chemical reaction parameter Kr shows decrease effects of concentration.

Key Words: Hall Current, Soret Effect, Chemical Reaction, MHD, Porous Medium, Oscillatory & Heat Source

1. Introduction:

Natural convection flow induced by buoyancy forces acting over bodies with different geometries in a fluid along a porous medium is prevalent in many natural phenomena and has varied and wide range of industrial applications, for example in atmospheric flows, the presence of pure air or water is not possible because of some foreign mass may be present naturally or artificially due to industrial emissions. Natural processes such as vaporization of mist and fog, photosynthesis are occur due to thermal and buoyancy forces developed as a result of difference in temperature or concentration or a combination of these two. Such configuration plays vital role in the industry based applications like heat exchange devices, cooling of molten metals, insulation systems, filtration, chemical catalytic reactors and processes. Considering these importance concepts of fluid flow we are able to construct so many problems by involving many parameters.

Investigation of hydro magnetic natural convection flow with heat and mass transfer in porous media has drawn considerable attentions of several researchers owing to its applications in astrophysics, geophysics, electronics, chemical and petroleum industries. Under the same concept Oscillatory flows are associated with higher rates of heat and mass transfer. Many studies have been done to understand its characteristics in different systems such as reciprocating engines, pulse combustors and chemical reactors etc. Oscillatory and modulated flows are associated applications in heat and mass transfer. The energy flux caused by a composition gradient is called the Dufour or diffusion –thermo effect. Temperature gradients can also create mass fluxes, and this is the soret or thermal-diffusion effect. The Soret effect, for instance, has been utilized for isotope separation, and in mixtures between gases with very light molecular weight .For medium molecular weight the dufour effect was found to be of a considerable magnitude such that it cannot be neglected.

Due to temperature gradients plays vital role in fluid flow, Ahmed N and Kalita H [1] studied the effects of temperature gradients in Oscillatory MHD free convective flow through a porous medium with mass transfer and chemical reaction. In addition to it MHD flow along a vertical porous plate is much importance in various fields like MHD energy generators, MHD flow – meters etc., keeping in view of the importance of such importance Ahmed S [2] investigated the Effects of unsteady free convective MHD flow through a porous medium bounded by an infinite vertical porous plate. Investigation of hydromagnetic natural convection flow in a rotating medium considerable due to importance of its application in various areas like geophysics, Earth magnetic field etc., under these view Attaia H.A., Kotb N.A [3] have found the important results of heat and mass transfer of fluid flow over a Rotating Disk in porous medium.

In all these investigations, analytical or numerical solution is obtained assuming conditions for fluid velocity and temperature at the plate as continuous and well defined. Keeping in view this fact, several researchers investigated free convection flow from a vertical porous plate with variable permeability like Chaudhary R.C [5] investigated Three dimensional coquette flow and heat transfer through a porous medium with variable permeability. In similar way Gersten K and Gross J.F [6] have studied Flow and heat transfer along a plane wall with periodic suction. Gupta G.D and Johari Rajesh [7] have developed the concepts of fluid flow over a past a porous plate. It is noticed that heat transfer plays a vital role in all engineering aspect keeping this view of importance, Hossain M.A, et.al [8] have studied Heat transfer response of MHD free convection flow along a vertical plate to surface temperature oscillations. Under this view, Kim Y.J [9] is investigated Unsteady MHD convective heat transfer past a semi –infinite vertical porous moving plate with variable suction.

It is noticed that heat transfer of fluid flow affects the velocity of fluid flow in various aspects keeping this view Lighthill M.J [10] studied the response of laminar skin-friction and heat transfer to fluctuations in the stream velocity. Mishra S.P and Mudali J.G [11] have investigated the combined free and forced convection effects on the magneto hydrodynamic flow through a porous medium channel. Moreover, several engineering processes occur at very high temperature where the knowledge of radiative heat transfer becomes indispensible for the design of pertinent equipment. Nuclear power plants, gas turbines and various propulsion devices for aircraft, missiles are examples of such area. It worthy to note that like convection/conduction the governing equations taking into account the effects of thermal radiation become importance keep this view of importance, Mohamed et.al [12] investigated Radiation effects on unsteady MHD free convection with hall current near an infinite vertical porous plate.

Extensions of these concepts, Palani G, Abbas I.A [13] have investigated free convection MHD free flow with thermal radiation from an impulsively started vertical plate. Due to importance of chemical reaction in fluid flow in various industrial application, under these view Rabin N.Barik et.al [14] have investigated the chemical reaction on MHD oscillatory flow through a porous medium bounded by two vertical porous plates with heat source and soret effect. In an ionized gas, when the strength of magnetic field is large one cannot neglect the effect of hall current. These Hall currents are very important and produce considerable changes in the flow domain. Due to importance of hall current on MHD convection flows, many authors carried out hall current problems of MHD generators and Hall accelerators. Singh K.D et.al [15] have investigated the effect of hall current on oscillatory MHD flow through a porous medium bounded by rotating porous channel. Singh K.D. and Rana S.K [16] studied the heat transfer of three dimensional fluid flows over a porous medium. Sumathi K et.al [17] have investigated the heat and mass transfer of in an Unsteady three dimensional mixed convection flow past an infinite vertical porous plate with cosinusoidally fluctuating temperature.

The objective of this paper is to analysis the effect of Hall Current on Oscillatory Rotation flow along an infinite vertical porous plate with soret effect and temperature varying cosinusoidally with time dependent in presence of chemical reaction. The aim of the present study is to extend the work of Anuradha et.al [4] by including the soret effect.

2. Formulation of Problem:

We consider the flow of an electrically conducting viscous incompressible fluid flow along a infinite vertical porous plate. The flow is oriented vertically upward along the x' - axis. The entire system is assumed to be rotating with angular velocity Ω' about z' axis. Choose the origin at the plate lying in $x'y'$ plane. We assume that the plate temperature, concentration and free stream velocity are varying cosinusoidally with respect to time. Hence, all the physical properties of the fluid are functions of y' and t' except the pressure.

$$\frac{\partial w'}{\partial z'} = 0 \;;\; w' = w_0 \quad \text{(Constant)} \tag{1}$$

$$\frac{\partial u'}{\partial t'} + w_0\frac{\partial u'}{\partial z'} = -\frac{1}{\rho}\frac{\partial p'}{\partial x'} + \upsilon\frac{\partial^2 u'}{\partial z'^2} + 2\Omega' v' + \frac{\sigma B_0^{\,2}}{\rho(1+m^2)}(mv' - u') + g\beta(T' - T_\infty) + g\beta_c(C' - C_\infty) - \frac{\upsilon}{k'}u' \tag{2}$$

$$\frac{\partial v'}{\partial t'} + w_0\frac{\partial v'}{\partial z'} = -\frac{1}{\rho}\frac{\partial p'}{\partial y'} + \upsilon\frac{\partial^2 v'}{\partial z'^2} - 2\Omega' u' - \frac{\sigma B_0^{\,2}}{\rho(1+m^2)}(mu' + v') - \frac{\upsilon}{k'}v' \tag{3}$$

$$\frac{\partial T'}{\partial t'} + w_0\frac{\partial T'}{\partial z'} = \frac{k}{\rho C_p}\frac{\partial^2 T'}{\partial z'^2} - \frac{Q}{\rho C_p}(T' - T_\infty) \tag{4}$$

$$\frac{\partial C'}{\partial t'} + w_0\frac{\partial C'}{\partial z'} = D\frac{\partial^2 C'}{\partial t'^2} + \frac{D_m k_T}{T_m}\frac{\partial^2 T'}{\partial z'^2} - R'\left(C' - C_\infty\right) \tag{5}$$

$$u'=0, v'=0, T'=T_0+\varepsilon\left(T_0-T_\infty\right)\cos\omega' t', C'=C_0+\varepsilon\left(C_0-C_\infty\right)\cos\omega' t' \text{ at } z'=0$$
$$u'=U'(t')=U_0\left(1+\cos\omega' t'\right), v'=0, T'\to T_\infty, C'\to C_\infty \text{ at } z'\to\infty \qquad (6)$$

Eliminating the modified pressure gradient in equation (2), (3) then we get the equation like as follows

$$\frac{\partial u'}{\partial t'}+w_0\frac{\partial u'}{\partial z'}=\upsilon\frac{\partial^2 u'}{\partial z'^2}+\frac{dU'}{dt'}+2\Omega' v'+\frac{\sigma B_0^{\,2}}{\rho\left(1+m^2\right)}\left(mv'-u'+U'\right)+$$
$$g\beta(T'-T_\infty)+g\beta_c(C'-C_\infty)-\frac{\upsilon}{k'}\left(u'-U'\right) \qquad (7)$$

$$\frac{\partial v'}{\partial t'}+w_0\frac{\partial v'}{\partial z'}=\upsilon\frac{\partial^2 u'}{\partial z'^2}+2\Omega'\left(u'-U'\right)+\frac{\sigma B_0^{\,2}}{\rho(1+m^2)}(mu'+v'-mU')-\frac{\upsilon}{k'}v' \qquad (8)$$

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

$$\eta=\frac{z'}{d}, t=\omega' t', u=\frac{u'}{U_0}, v=\frac{v'}{U_0'}, \Omega=\frac{\Omega' d^2}{v}, \lambda=\frac{\omega_0 d}{v}, \phi=\frac{Q_0 d^2}{\mu C_p}, M=B_0 d\sqrt{\frac{\sigma}{\mu}}$$
$$Gr=\frac{g\beta v\left(T_0-T_\infty\right)}{U_0 w_0^{\,2}}, Gm=\frac{g\beta_c v\left(C_0-C_\infty\right)}{U_0 w_0^{\,2}}, K=\frac{K_r' d^2}{v}, C=\frac{C'-C_\infty}{C_0-C_\infty}, \theta=\frac{T'-T_\infty}{T_0-T_\infty} \qquad (9)$$
$$Pr=\frac{\mu C_p}{k}, K=\frac{K'}{d^2}, \omega=\frac{\omega' d^2}{v}, S_0=\frac{D_m k_T\left(T_0-T_\infty\right)}{T_m v\left(C_0-C_\infty\right)}$$

Substituting equation (9) in equations (4), (5), and (7), (8) we get

$$\omega\frac{\partial u}{\partial t}+\lambda\frac{\partial u}{\partial\eta}=\frac{\partial^2 u}{\partial\eta^2}+\omega\frac{dU}{dt}+2\Omega v+\frac{M^2}{1+m^2}\left(mv-u+U\right)+Gr\theta\lambda^2+GmC\lambda^2-\frac{u-U}{k} \qquad (10)$$

$$\omega\frac{\partial v}{\partial t}+\lambda\frac{\partial v}{\partial\eta}=\frac{\partial^2 u}{\partial\eta^2}-2\Omega\left(u-U\right)-\frac{M^2}{1+m^2}\left(mu+v-mU\right)-\frac{\upsilon}{k} \qquad (11)$$

$$\omega\frac{\partial\theta}{\partial t}+\lambda\frac{\partial\theta}{\partial\eta}=\frac{1}{Pr}\frac{\partial^2\theta}{\partial\eta^2}-\phi\theta \qquad (12)$$

$$\omega\frac{\partial C}{\partial t}+\lambda\frac{\partial C}{\partial\eta}=\frac{1}{Sc}\frac{\partial^2 C}{\partial\eta^2}+S_0\frac{\partial^2\theta}{\partial\eta^2}-RC \qquad (13)$$

With the following boundary conditions

$$u=0, v=0, \theta=1+\frac{\varepsilon}{2}\left(e^{i\omega t}+e^{-i\omega t}\right), C=1+\frac{\varepsilon}{2}\left(e^{i\omega t}+e^{-i\omega t}\right) \text{ at } z=0$$
$$u=1+\frac{\varepsilon}{2}\left(e^{i\omega t}+e^{-i\omega t}\right), v=0, \theta=0, C=0 \text{ at } z\to\infty \qquad (14)$$

Now Introducing the Complex Velocity $q=u+iv$, we express the Equation (10) and (11) can be combined into a single equation of the form

$$\omega\frac{\partial q}{\partial t}+\lambda\frac{\partial q}{\partial\eta}=\frac{\partial^2 q}{\partial\eta^2}+\omega\frac{dU}{dt}-S(q-U)+Gr\theta\lambda^2+GmC\lambda^2 \qquad (15)$$

Where $S=2\Omega I+\frac{M^2}{1+m^2}\left(1+Im\right)+\frac{1}{k}$

With boundary condition,

$$q=0, T=1+\varepsilon e^{i\omega t}, C=1+\varepsilon e^{i\omega t} \text{ at } z=0$$
$$q=1, T\to 0, C\to 0 \text{ at } z\to\infty \qquad (16)$$

3. Method of Solution:

To solve equations (12), (13) and (15), Assuming ε to be small so that one can express q, θ *and* C as a regular perturbation series interms ε as in the neighborhood of the plate as

$$\theta = \theta_0(\eta) + \frac{\varepsilon}{2}\theta_1(\eta)e^{i\omega t} + \frac{\varepsilon}{2}\theta_2(\eta)e^{-i\omega t}$$

$$C = C_0(\eta) + \frac{\varepsilon}{2}C_1(\eta)e^{i\omega t} + \frac{\varepsilon}{2}C_2(\eta)e^{-i\omega t} \quad (17)$$

$$q = q_0(\eta) + \frac{\varepsilon}{2}q_1(\eta)e^{i\omega t} + \frac{\varepsilon}{2}q_2(\eta)e^{-i\omega t}$$

Using the equation (17) in equations (12), (13) & (15) we get the set of equations

$$\frac{d^2\theta_0}{d\eta^2} - \lambda \Pr\frac{d\theta_0}{d\eta} - \phi \Pr\theta_0 = 0 \quad (18)$$

$$\frac{d^2\theta_1}{d\eta^2} - \lambda \Pr\frac{d\theta_1}{d\eta} - (\phi + i\omega)\Pr\theta_1 = 0 \quad (19)$$

$$\frac{d^2\theta_2}{d\eta^2} - \lambda \Pr\frac{d\theta_2}{d\eta} - (\phi - i\omega)\Pr\theta_2 = 0 \quad (20)$$

$$\frac{d^2C_0}{d\eta^2} - \lambda Sc\frac{dC_0}{d\eta} - ScRC_0 = -S_0Sc\frac{d^2\theta_0}{d\eta^2} \quad (21)$$

$$\frac{d^2C_1}{d\eta^2} - \lambda Sc\frac{dC_1}{d\eta} - Sc(R + i\omega)C_1 = -S_0Sc\frac{d^2\theta_1}{d\eta^2} \quad (22)$$

$$\frac{d^2C_2}{d\eta^2} - Sc\,Re\frac{dC_2}{d\eta} - Sc\,Re(R - i\omega)C_2 = -S_0Sc\,Re\frac{d^2\theta_2}{d\eta^2} \quad (23)$$

$$\frac{d^2q_0}{d\eta^2} - \lambda\frac{dq_0}{d\eta} - Sq_0 = -SU_0 - Gr\lambda^2\theta_0 - Gm\lambda^2C_0 \quad (24)$$

$$\frac{d^2q_1}{d\eta^2} - \lambda\frac{dq_1}{d\eta} - (S + i\omega)q_1 = -(S + i\omega)U_0 - Gr\lambda^2\theta_1 - Gm\lambda^2C_1 \quad (25)$$

$$\frac{d^2q_2}{d\eta^2} - \lambda\frac{dq_2}{d\eta} - (S - i\omega)q_2 = -(S - i\omega)U_0 - Gr\lambda^2\theta_2 - Gm\lambda^2C_2 \quad (26)$$

Solving the equations (18) to (26) we get the solutions as below

$$\theta = e^{m_2 y} + \frac{\varepsilon}{2}e^{m_4 y}e^{I\omega t} + \frac{\varepsilon}{2}e^{m_6 y}e^{-I\omega t} \quad (27)$$

$$C = A_8e^{m_8 y} + A_9e^{m_2 y} + \frac{\varepsilon}{2}\left(A_{11}e^{m_{10} y} + A_{12}e^{m_4 y}\right)e^{I\omega t} + \frac{\varepsilon}{2}\left(A_{14}e^{m_{12} y} + A_{15}e^{m_6 y}\right)e^{-I\omega t} \quad (28)$$

$$q = A_{17}e^{m_{14} y} + A_{18}e^{m_2 y} + A_{19}e^{m_8 y} + A_{20}e^{m_2 y} + U_0 + \frac{\varepsilon}{2}\begin{pmatrix} A_{22}e^{m_{16} y} + A_{23}e^{m_4 y} + \\ A_{24}e^{m_{10} y} + A_{25}e^{m_4 y} + U_0 \end{pmatrix}e^{I\omega t}$$
$$+ \frac{\varepsilon}{2}\left(A_{27}e^{m_{18} y} + A_{28}e^{m_6 y} + A_{29}e^{m_{12} y} + A_{30}e^{m_6 y} + U_0\right)e^{-I\omega t} \quad (29)$$

3.1 Skin Friction: The Skin friction for various values of M is given by

$$\tau_\omega = -\mu\left(\frac{\partial q}{\partial y}\right)_{y=0} = A_{17}m_{14} + A_{18}m_2 + A_{19}m_8 + A_{20}m_2 + \frac{\varepsilon}{2}\begin{pmatrix} A_{22}m_{16} + A_{23}m_4 + \\ A_{24}m_{10} + A_{25}m_4 \end{pmatrix}e^{I\omega t}$$
$$+ \frac{\varepsilon}{2}\left(A_{27}m_{18} + A_{28}m_6 + A_{29}m_{12} + A_{30}m_6\right)e^{-I\omega t} \quad (30)$$

3.2 Heat Flux: The rate of heat transfer at the wall of non-dimensional nusselt number is given by

$$Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = m_2 + \frac{\varepsilon}{2} m_4 e^{I\omega t} + \frac{\varepsilon}{2} m_6 e^{-I\omega t} \tag{31}$$

3.3 Mass Flux: The rate of mass transfer at the wall of non-dimensional Chemical reaction parameter is given by

$$\left(\frac{\partial C}{\partial y}\right)_{y=0} = -\left(A_8 m_8 + A_9 m_2 + \frac{\varepsilon}{2}\left(A_{11} m_{10} + A_{12} m_4\right) e^{I\omega t} + A_{12} m_4 e^{m_4}\right) e^{I\omega t} + \frac{\varepsilon}{2}\left(A_{14} m_{12} + A_{15} m_6\right) e^{-I\omega t} \tag{32}$$

4. Results and Discussions:

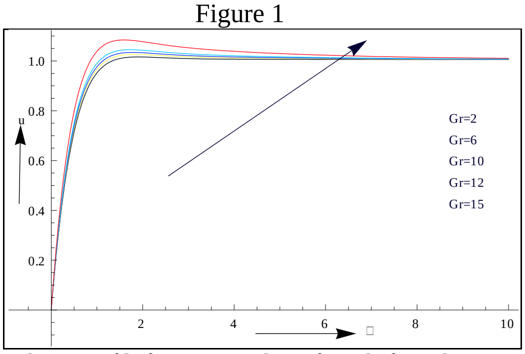
The effects of Oscillatory flow through a porous medium along infinite vertical porous plates in the presence of Hall Current and Soret Effect with homogeneous chemical reaction under the influence of uniform magnetic field has been studied. The effects of parameters in the fluid flow are thoroughly analyzed and given in the form of graph to easily understand.

4.1 Velocity Field: The increasing of Grashof number for heat transfer Gr, Soret effect S_0,Hartmann number M, Rotation effect Ω accelerate the main and cross velocity of the fluid flow, Hall Effects m accelerate the cross velocity but retards the main velocity. Modified Grashof Number Gm, retards the main velocity of the flow field. Like that involving various parameters to analysis the fluid flow along infinite vertical porous plate. Skin friction shows increase effects while increase of Hartmann number.

4.2 Temperature Field: Temperature profiles of the flow field with the effected parameters like Prandlt number Pr, Permeability parameter K, Grashof Number Gr, Heat Source are graphically shown its effects on the flow field. Temperature profile goes on decrease while growing parameter Prandlt (Pr) and Heat Source. Heat flux is increase while increases of heat source, all the effect parameters are shown in graphically.

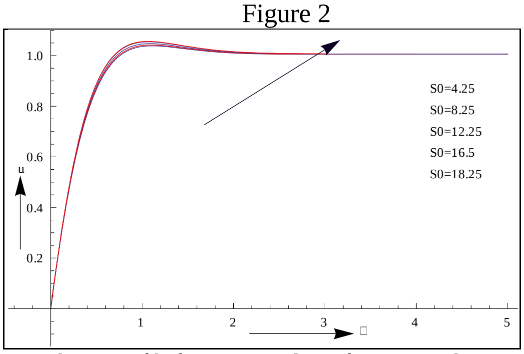
4.3 Concentration Field: Schmidt Number and Chemical reaction parameter plays important role in the concentration fluid flow field. The effects of these parameters on the fluid flow field graphically shown. While growing Schmidt number (Sc) and chemical reaction parameter (Kr) decrease the concentration boundary layer thickness of the flow in similar way the effects of mass flux are decrease while growing of chemical reaction parameter. All the parameters which are effect the heat and mass transfer are graphically show they are affected by the parameters.

Figure 1



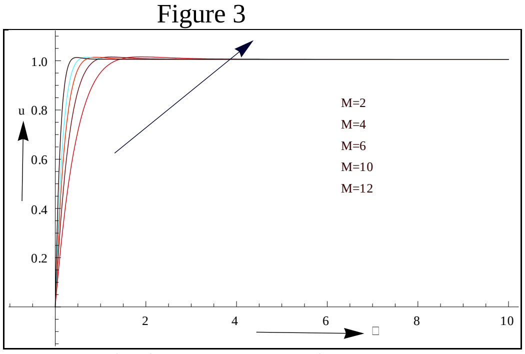
Velocity Profile for various values of Grashof Number
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25; Kr=6.25;Gr=0.5; S_0= 2; Ω =1.0; M=4.25; m=0.25; K=1.5; Gm= 2; U_0=1.0;

Figure 2



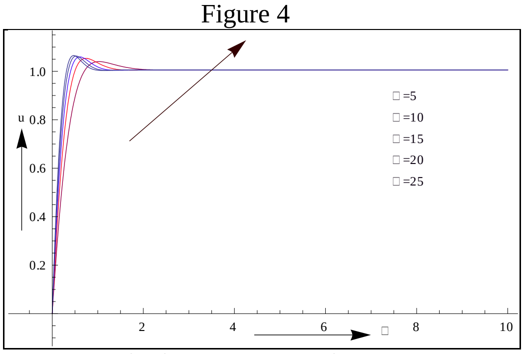
Velocity Profile for various values of Soret Number
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25; Kr=6.25; m=0.25; K=1.5;M=4.25; Gm= 2; U_0=1.0; Ω =1.0

Figure 3



Velocity Profile for various values of Hartmann Number

Figure 4

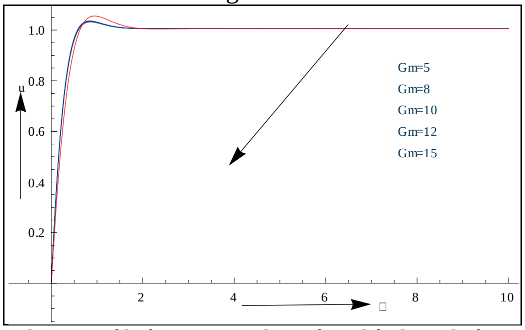


Velocity Profile for various values of Rotation Parameter

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 2; Ω =1.0; m=0.25; K=1.5; Gr=2
Gm= 2; U_0=1.0;

Figure 5

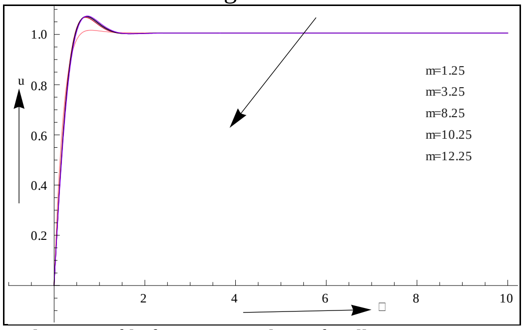


Velocity Profile for various values of Modified Grashof Number

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 2 ;m=0.25; K=1.5;M=2
Gm= 2; U_0=1.0; Gr=2

Figure 6

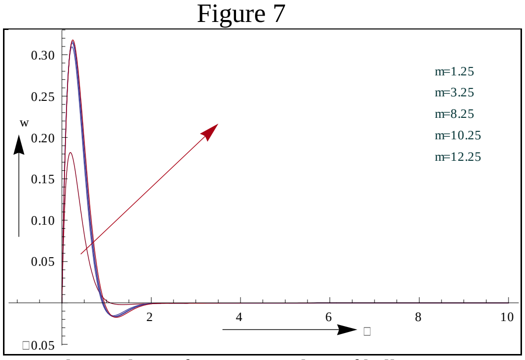


Velocity Profile for various values of Hall Parameter

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 2; Ω =1.0; m=0.25; K=1.5; Gr=2
Ω =10.0; U_0=1.0;

Figure 7

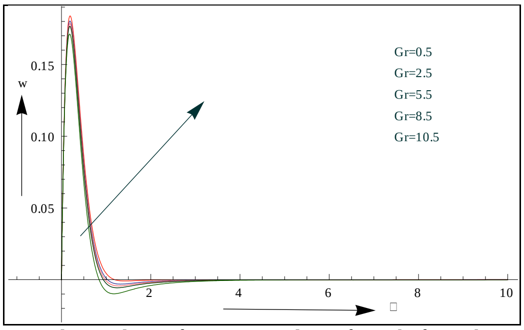


Secondary Velocity for various values of hall parameter

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 2; K=1.5; U_0=1.0; Gr=2; Ω =1.0; Ω =10.0
Gm=2

Figure 8

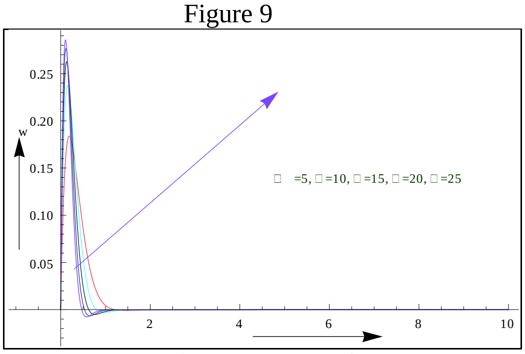


Secondary Velocity for various values of Grashof Number

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 0.15; Ω =1.0; m=0.25; K=1.5; Gr=2
U_0=1.0; Gm=2

Figure 9

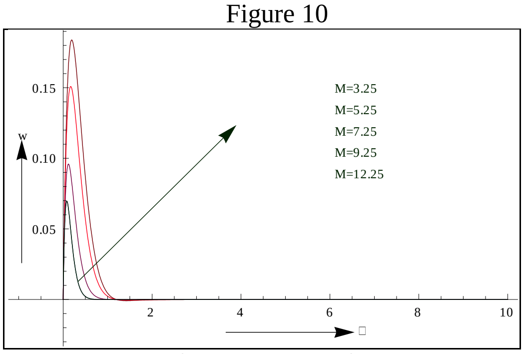


Secondary Velocity for various values of Rotation parameter

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0=0.15; K=1.5; U_0=1.0; Ω =1.0; Ω =10.0
Gm=2; m=0.5

Figure 10

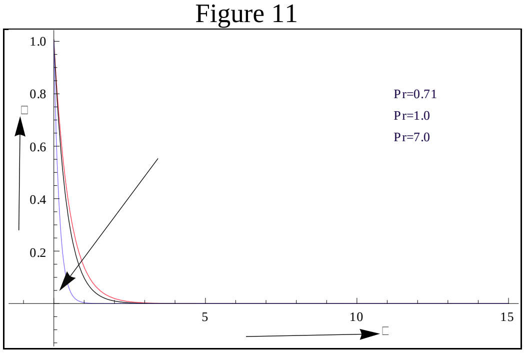


Secondary Velocity for various values of Hartmann parameter

Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0= 2;K=1.5; Gr=2; U_0=1.0;Gm=2

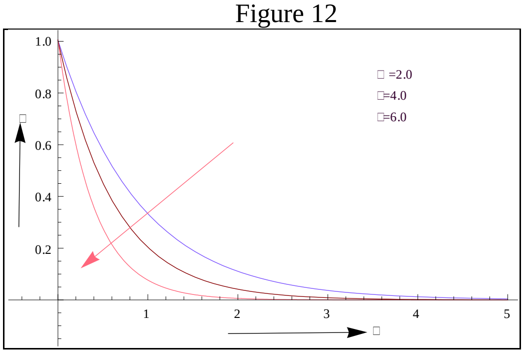
Figure 11



Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2;Sc=0.25;

Kr=6.25; S_0=0.15; K=1.5; U_0=1.0; Ω =1.0; Gm=2;

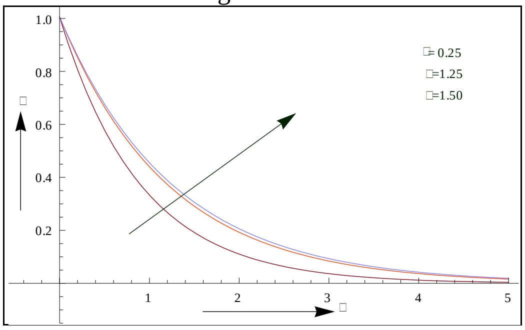
Figure 12



Temperature Profile for various values of Prandtl Number
ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =2.0;

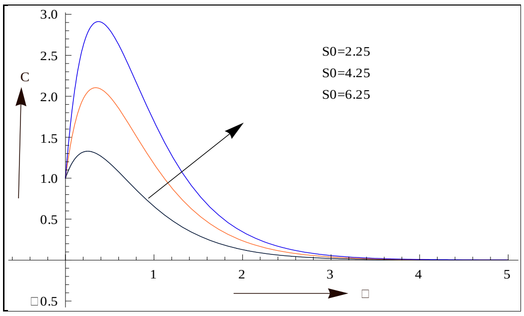
Temperature Profile for various values of Rotation Parameter
ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =2.0;

Figure 13



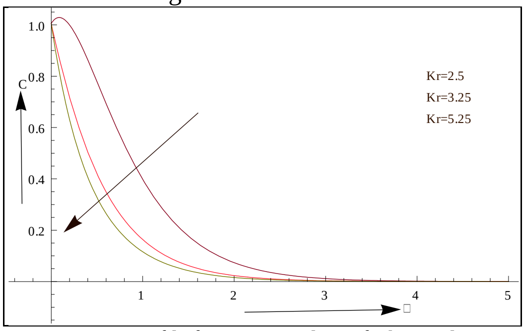
Temperature Profile for various values of λ
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =2.0;

Figure 14



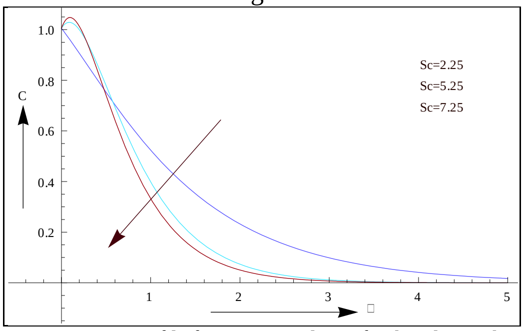
Concentration Profile for various values of Soret Number
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =6.0; Sc=0.25; Kr=3.25

Figure 15



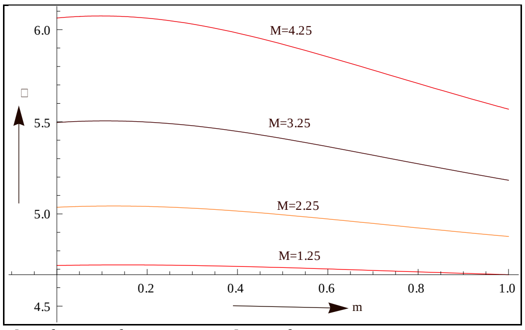
Concentration Profile for various values of Chemical Reaction
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =2.2; Sc=0.25 S_0=1.15

Figure 16



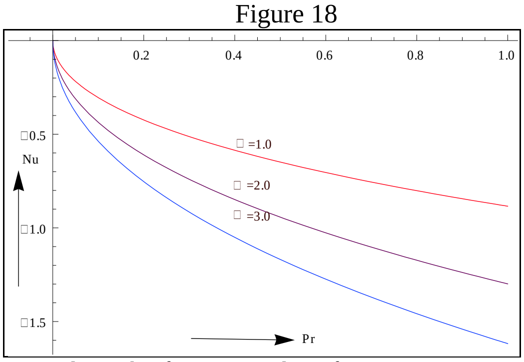
Concentration Profile for various values of Schmidt Number
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.25; ϕ =2.2; S_0=1.15; Kr=6.25;

Figure 17



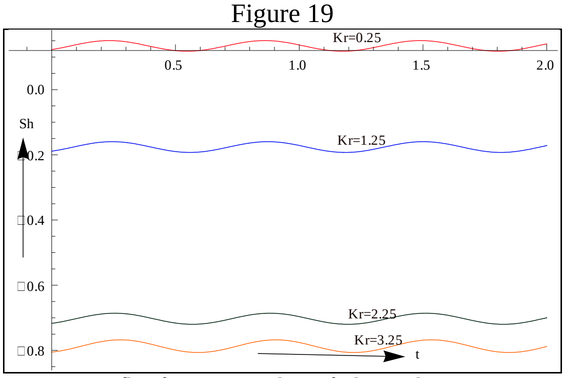
Skin friction for various values of M
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2; Sc=0.25 Kr=6.25; S_0=1.15; K=1.5; Gr=2; U_0=1.0; Gm=1

Figure 18



Nusselt Number for various values of Heat Source
Pr=0.71; ω =1.0;t=1.0; ε =0.01; ϕ =2.0

Figure 19



Mass flux for various values of Chemical reaction
Pr=0.71; ω =1.0;t=1.0; ε =0.01; λ =0.2; ϕ =2.2; S_0=0.2; Kr=6.25

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.

- ✓ Soret (S_0) accelerates the main and cross velocity of the fluid flow.
- ✓ Growing of Grashof Number (Gr) Hartmann number (M) accelerates the transient velocity of the fluid flow but
- ✓ Growing of Hall Parameter (m) retards the main velocity flow but the accelerates the cross velocity of the fluid flow.
- ✓ Prandtl number decreases the boundary layer of temperature profile of the fluid flow along a porous plat.
- ✓ The Chemical reaction parameter (Kr) and Schmidt Number (Sc) both retards of the Concentration of Mass while both are grown.
- ✓ The variation of skin friction at the wall against the different values of Hartmann number (M).It observed increase effects exists if the Hartmann number (M) is increase.
- ✓ The rate of heat transfer at the wall is increase for the different values heat source.
- ✓ The rate of mass transfer at the wall is decrease for the different values of chemical reaction.

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Appendix:

$$M_2 = \frac{\lambda Pr - \sqrt{(\lambda Pr)^2 + 4\phi Pr}}{2}$$
$$M_4 = \frac{\lambda Pr - \sqrt{(\lambda Pr)^2 + 4(\phi + I\omega)Pr}}{2}$$
$$M_6 = \frac{\lambda Pr - \sqrt{(\lambda Pr)^2 + 4(\phi - I\omega)Pr}}{2}$$
$$M_8 = \frac{\lambda Sc - \sqrt{Sc^2 + 4KrSc}}{2}$$
$$M_{10} = \frac{\lambda Sc - \sqrt{\lambda^2 Sc^2 + 4(Kr + I\omega)Sc}}{2}$$
$$M_{12} = \frac{\lambda Sc - \sqrt{\lambda^2 Sc^2 + 4(Kr - I\omega)Sc}}{2}$$
$$M_{14} = \frac{\lambda - \sqrt{\lambda^2 + 4S}}{2}$$
$$M_{16} = \frac{\lambda - \sqrt{\lambda^2 + 4(S + I\omega)}}{2}$$
$$M_{18} = \frac{\lambda - \sqrt{\lambda^2 + 4(S - I\omega)}}{2}$$
$$A_{17} = -(A_{18} + A_{19} + A_{20} + U_0)$$
$$A_{22} = -(A_{23} + A_{24} + A_{25} + U_0)$$
$$A_{27} = -(A_{28} + A_{29} + A_{30} + U_0)$$
$$A_{14} = 1 - A_{15}$$
$$A_{15} = \frac{-S_0 Sc M_6{}^2}{M_6{}^2 - Sc\lambda M_6 - (Kr - I\omega)Sc}$$
$$A_{28} = \frac{-Gr\lambda^2}{M6^2 - \lambda M6 - (S - I\omega)}$$
$$A_{29} = \frac{-Gm\lambda^2 A_{14}}{M_{12}{}^2 - \lambda M_{12} - (S - I\omega)}$$
$$A30 = \frac{-Gm\lambda^2 A_{15}}{M_6{}^2 - \lambda M_6 - (S - I\omega)}$$
$$A12 = \frac{-S_0 Sc M_4{}^2}{M_4{}^2 - Sc\lambda M_4 - (Kr + I\omega)Sc}$$
$$A_{11} = 1 - A_{12}$$
$$A_{23} = \frac{-Gr\,\lambda^2}{M_4 - RM_4 - (S + Iw)}$$
$$A_{24} = \frac{-Gm\,\lambda^2 A_{11}}{M_{10}{}^2 - RM_{10} - (S + Iw)}$$
$$A_{25} = \frac{-Gm\,\lambda^2 A_{12}}{M_4{}^2 - \lambda M_4 - S}$$
$$A_{18} = \frac{-Gr\,\lambda^2}{M_2{}^2 - \lambda M_2 - S}$$
$$A_{19} = \frac{-Gm\,\lambda^2 A_8}{M_8{}^2 - RM_8 - S}$$
$$A_{20} = \frac{-Gm\,\lambda^2 A_9}{M_2{}^2 - RM_2 - S}$$
$$A_8 = 1 - A_9$$
$$A_9 = \frac{-S0ScM_2{}^2}{M_2{}^2 - Sc\,\lambda M_2 - KrSc}$$