RESEARCH ARTICLE OPEN ACCESS

Hall Effect on Unsteady Heat and Mass Transfer Oscillatory Flow through Porous Medium under Slip Condition

R.Panneerselvi *, P.Gowri **
*(Department of Mathematics, PSGR Krishnammal College for women, Coimbatore, India
Email: panneerselvir@psgrkc.ac.in)*
*** (Department of Mathematics, Sri Krishna Arts and Science College, Coimbatore, India,
Email: pa.gowri75@gmail.com)*

ABSTRACT
Hall Effect on unsteady heat and mass transfer MHD oscillatory flow through a porous medium under slip condition is studied. An approximate solution of the governing equations for fully developed flow with radiative heat transfer is obtained in closed form. Detailed computations on the influence of Grashof number, Hartmann number, slip parameter, porosity parameter, radiation parameter, mass Grashof number, Hall parameter, Schmidt number and frequency of the oscillation on velocity, temperature, concentration, skin friction, rate of heat and mass transfer are discussed with the help of graphs.
Keywords: Hall Effect, Oscillating frequency, Porous medium, radiative heat transfer, Slip parameter

Date of Submission: 25-08-2017 Date of acceptance: 13-09-2017

I. INTRODUCTION

Convective motion in a porous medium has attracted considerable attention from many researches because of its application in geophysics, oil recovery technique, thermal insulation, engineering and heat storage. The study of electrically conducting fluid has many applications in engineering problems such as magnetohydrodynamic (MHD) generators plasma studies, nuclear reactors, geothermal energy extraction and boundary layer in the field of aerodynamics. In view of the applications of free convective and heat transfer flows through porous medium under the influence of magnetic field many researchers have studied magnetohydrodynamic free convective heat transfer flow in a porous medium.

In practical applications, the particle adjacent to a solid surface no longer takes the velocity of the surface. The particle at the surface has a finite tangential velocity, it slips along the surface. Such a flow regime is called the slip flow regime and its effect cannot be neglected. The fluid slippage phenomenon at the solid boundaries appears in many applications such as micro channels or nano channels. The slip flow regime can also occur in the working fluid containing concentrated suspensions. The effect of slip conditions on unsteady flow with Hall Effect in a channel with permeable boundaries has been discussed.

Ram and Mishra, (1976) analyzed unsteady flow through MHD porous media. Raptis et al (1983) studied the unsteady free convective flow through a porous medium bounded by an infinite vertical plate. Mansutti et al (1993) have studied the steady flow of non- Newtonian fluids past a porous plate with suction or injection. Unsteady free convection flow past a vertical porous plate was studied by Anwar (1998). Alagoa et al (1998) studied MHD optically transparent free convection flow with radiative heat transfer in porous media with time-dependent suction using an asymptotic approximation, showing that thermal radiation exerts a significant effect on the flow dynamics. Hazem A. Attia (2002) analyzed thermal radiation effect on transient, two-dimensional hydromagnetic free convection flow along a vertical surface in a highly porous medium using the Roseland diffusion approximation for the radiative heat flux in the energy equation, for the case where free- stream velocity of the fluid vibrates about mean constant value and the surface absorbs the fluid with constant velocity.

MHD unsteady free convection Walter’s memory flow with constant suction and heat sink was studied by Ramana et al (2007). HariKrishna & Jagadeeswara Pillai (2010) studied Hall Current effects on unsteady free convection flow past an infinite vertical plate with constant suction and heat sink. In all these investigations “no-slip” boundary condition is considered for the velocity. The phenomenon of slip-flow regime has attracted the attention of a large number of scholars due to its wide ranging application. The problem of the slip flow regime is very important in this era of modern science, technology and vast ranging industrialization. Soltani and Yilmazer (1998) analyzed Slip velocity and slip layer thickness in flow of concentrated suspensions. Watanebe, Yanuar and Mizunuma (1998) studied Slip of Newtonian fluids at solid boundary. Singh and Rakesh kumar (2011) have analyzed Fluctuating thermal and mass diffusion on unsteady MHD convection of a micro polar fluid through a porous medium past a vertical plate in slip-flow regime. Khaled and Vafai (2004) obtained the closed form solutions for steady periodic and transient velocity field under slip condition. The effect of slip conditions on the MHD steady flow in a channel with permeable boundaries has been discussed by Makinde and Osalusi (2006).

Hall Effect on the unsteady incompressible MHD fluid flow with slip conditions and porous walls studied by Zaman (2013). Gorelov and Kogan (1969) studied Solution of temperature jump (Knudsen layer flow) and linear heat transfer problems for two parallel plates in a rarefied gas. Effects of velocity slip and temperature jump on the boundary layer flow and heat transfer over a wedge have been studied by Wang (2011). Unsteady Heat and Mass Transfer of Chemically Reacting Micropolar Fluid in a Porous Channel with Hall and Ion Slip Currents was examined by Odelu Ojjela and Naresh Kumar (2014). Misra and Adhikary (2016) studied the effect of MHD oscillatory channel flow, heat and mass transfer in a physiological fluid in presence of chemical reaction.

This paper deals with the Hall Effect on unsteady heat and mass transfer oscillatory flow through a porous medium under slip boundary condition. Here, the effect of velocity, concentration, temperature, shear stress, heat transfer and mass transfer are analyzed graphically.

II. MATHEMATICAL FORMULATION

Consider the flow of a conducting optically thin fluid in a channel filled with saturated porous medium under the influence of an externally applied homogeneous magnetic field and radiative heat transfer. It is assumed that the fluid has a small electrical conductivity and the electromagnetic force produced is very small. Take a Cartesian coordinate system(x, y), where x lies along the center of the channel, y is the distance measured in the normal section. By assuming a Boussinesq incompressible fluid model, the equations governing the motion are given as:

$$\frac{\partial u'}{\partial t'} = -\frac{1}{\rho}\frac{\partial p'}{\partial x'} + \nu\frac{\partial^2 u'}{\partial y'^2} - \frac{\nu}{K'}u' - \frac{\sigma_e B_0{}^2 u'}{(1+m^2)\rho} + g\beta(T'-T_0') + g\beta(C'-C_0') \qquad (1)$$

$$\frac{\partial T'}{\partial t'} = \frac{k}{\rho C_P}\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho C_P}\frac{\partial q'}{\partial y'} \qquad (2)$$

$$\frac{\partial C'}{\partial t} = D\frac{\partial^2 C'}{\partial y^2} - Kr(C'-C_0') \qquad (3)$$

with boundary conditions

$$u' - \gamma*\frac{\partial u'}{\partial y'} = 0,\ T' = T_0',\ C' = C_0' \text{ on } y' = 0$$

$$u' = 0, T' = T_0' + (T_\omega' - T_0')\cos\omega' t',$$

$$C' = C_0' + (C_\omega' - C_0')\cos\omega' t' \quad y' = 1 \qquad (4)$$

Where,

u'	-	axial velocity
Kr	-	chemical reaction coefficient
t'	-	time
ω'	-	frequency of the oscillation
T'	-	fluid temperature
P	-	pressure
g	-	gravitational force
C_p	-	specific heat at constant pressure
k	-	thermal conductivity
q'	-	radiative heat flux
β	-	coefficient of volume expansion
K'	-	permeability coefficient
B_0	-	electromagnetic induction
σ_e	-	conductivity of the fluid
ρ	-	density of the fluid
ν	-	kinematic viscosity coefficient
D	-	mass diffusion coefficient
C'	-	fluid concentration

It is assumed that wall temperature T_0', T_ω' are high enough to induce radiative heat transfer and $\gamma*$ is the dimensionless slip parameter. It is also assumed that the fluid is optically thin with a relatively low density and the radiative heat flux is given by

$$\frac{\partial q'}{\partial y'} = 4\alpha^2(T_0{}' - T') \qquad (5)$$

Where α is the mean radiation absorption coefficient. The following dimensionless variables and parameters are introduced to nondimensionalize the governing equations

$$p = \frac{aP'}{\rho\,\nu\,U'},\ Da = \frac{K'}{a^2},\ S^2 = \frac{1}{Da},\ J = \frac{Kra}{U}\ Sc = \frac{\nu}{D},\ t = \frac{t'U}{a},\ Gr = \frac{g\beta(T_w{}'-T_0{}')a^2}{\nu\,U},\ c = \frac{g\beta(C_w{}'-C_0{}')a^2}{\nu\,U},$$
$$N^2 = \frac{4\alpha^2 a^2}{k},\quad \gamma = \frac{\gamma^*}{a},\quad Re = \frac{Ua}{\nu},\quad M_1 = \frac{1}{1+m^2},$$
$$\theta = \frac{T'-T_0'}{T_w'-T_0'},\quad x = \frac{x'}{a},\quad y = \frac{y'}{a},\quad u = \frac{u'}{U},\quad H^2 = \frac{a^2\sigma_e B_0^2}{\rho\,\nu},\ Pe = \frac{Ua\rho C_P}{k},\ \phi = \frac{C'-C_0'}{C_w'-C_0'}$$
(6)

where U is the mean flow velocity, the dimensionless governing equations (1) – (3) together with appropriate boundary conditions (4) can be written as

$$\mathrm{Re}\frac{\partial u}{\partial t} = -\frac{\partial \rho}{\partial x} + \frac{\partial^2 u}{\partial y^2} - (s^2 + H^2 M_1)u + Gr\theta + Gc\phi \quad (7)$$

$$Pe\frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2} + N^2\theta \quad (8)$$

$$\frac{\partial \phi}{\partial \tau} = Sc\frac{\partial^2 \phi}{\partial y^2} - J\phi \quad (9)$$

$$u - \gamma\frac{\partial u}{\partial y} = 0,\ \theta = 0,\ \phi = 0 \text{ on y = 0}$$

$$u = 0,\ \theta = \cos\omega t,\ \phi = \cos\omega t \text{ on y = 1} \quad (10)$$

III. METHOD OF SOLUTION

To solve equations (7) - (9) for purely oscillatory flow, let the pressure gradient; fluid velocity and temperature can be considered as

$$-\frac{\partial \rho}{\partial x} = \lambda(e^{i\omega t} + e^{-i\omega t}) \quad (11)$$

$$u(y,t) = u_0(y)e^{i\omega t} + u_1(y)e^{-i\omega t} \quad (12)$$

$$\theta(y,t) = \theta_0(y)e^{i\omega t} + \theta_1(y)e^{-i\omega t} \quad (13)$$

$$\phi(y,t) = \phi_0(y)e^{i\omega t} + \phi_1(y)e^{-i\omega t} \quad (14)$$

where $\lambda <$ 0 for favorable pressure, ω is the frequency of the oscillation. Substituting the above expressions (11) - (14) into equations (6), (7) and (8), we obtain

$$\frac{d^2u_0}{dy^2} - m_1^2 u_0 = -\lambda - Gr\theta_0 - Gc\phi_0 \quad (15)$$

$$\frac{d^2u_1}{dy^2} - m_2^2 u_1 = -\lambda - Gr\theta_1 - Gc\phi_1 \quad (16)$$

$$\frac{d^2\theta_0}{dy^2} + N_1^2\theta_0 = 0 \quad (17)$$

$$\frac{d^2\theta_1}{dy^2} + N_2^2\theta_1 = 0 \quad (18)$$

$$\frac{d^2C_0}{dy^2} - N_3^2\phi_0 = 0 \quad (19)$$

$$\frac{d^2C_1}{dy^2} - N_4^2\phi_1 = 0 \quad (20)$$

and the corresponding boundary conditions are

$$u_0 - \gamma\frac{du_0}{dy} = 0, u_1 - \gamma\frac{du_1}{dy} = 0, \theta_0 = \theta_1 = 0, \phi_0 = \phi_1 = 0$$

on y = 0

$$u_0 = u_1 = 0, \theta_0 = \theta_1 = 1/2, \phi_0 = \phi_1 = 1/2 \text{, on y = 1}$$

where

$$m_1 = \sqrt{s^2 + H^2 + \mathrm{Re}\, i\omega},\quad m_2 = \sqrt{s^2 + H^2 - \mathrm{Re}\, i\omega},$$

$$N_1 = \sqrt{N^2 - Pei\omega} \quad N_2 = \sqrt{N^2 + Pei\omega},$$

$$N_3 = \sqrt{\frac{J + iw}{Sc}},\quad N_4 = \sqrt{\frac{J - iw}{Sc}}$$

Equations (15) - (20) are solved and the solution for velocity, fluid temperature and concentration are given as follows

$$u(y,t) = \begin{pmatrix} A_1\cosh m_1 y + B_1\sinh m_1 y + \\ \lambda_1 + \eta_1 Gr\sin N_1 y + \eta_3 Gc\sin N_3 y \end{pmatrix} e^{i\omega t} + \begin{pmatrix} C_1\cosh m_2 y + D_1\sinh m_2 y + \\ \lambda_2 + \eta_2 Gr\sin N_2 y + \eta_4 Gc\sin N_4 y \end{pmatrix} e^{-i\omega t}$$

$$\theta(y,t) = \frac{1}{2}\left(\frac{\sin N_1 y}{\sin N_1}e^{i\omega t} + \frac{\sin N_2 y}{\sin N_2}e^{-i\omega t}\right)$$

$$\phi(y,t) = \frac{1}{2}\left(\frac{\sin N_3 y}{\sin N_3}e^{i\omega t} + \frac{\sin N_4 y}{\sin N_4}e^{-i\omega t}\right)$$

The shear stress at the lower wall of the channel is given by

$$\left(\frac{\partial u}{\partial y}\right)_{y=0} = \left[Bm_1 + \eta_1 GrN_1\right]e^{i\omega t} + \left[Dm_2 + \eta_2 GrN_2\right]e^{-i\omega t} \quad (25)$$

The rate of heat transfer across the channel's wall is given as

$$\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = \frac{1}{2}\left(\frac{N_1}{\sin N_1}e^{i\omega t} + \frac{N_2}{\sin N_2}e^{-i\omega t}\right) \quad (26)$$

The rate of mass transfer across the channel's wall is given as

$$\left(\frac{\partial \phi}{\partial y}\right)_{y=0} = \frac{1}{2}\left(\frac{N_3}{\sin N_3}e^{i\omega t} + \frac{N_4}{\sin N_4}e^{-i\omega t}\right) \quad (27)$$

IV. RESULT AND DISCUSSION

To study the effects of wall slip, magnetic field, radiation parameter, thermal buoyancy force, porosity of medium, Peclet number, Reynolds number and oscillations on flow-field numerical values are computed from analytical solution.

The velocity profiles for various non-dimensional parameters have been studied and presented in Figures 1 to 9. The velocity profiles for different slip parameter (γ =0.22, 0.26, 0.35, 0.40) are presented in Fig.1. It is observed that the velocity increases with increasing slip parameter.

The velocity profile for different Hartmann number (Ha = 0.01, 0.13, 0.19, 0.25) is shown in Fig.2. It is clearly known that the profile decreases with increasing Hartmann number.

The velocity profile for different Schmidt number (Sc = 0.2, 0.6, 1.0, 1.5) is shown in Fig.3. It exhibits that the velocity increases with increasing Schmidt number.

Fig.4 exhibits the velocity profile for different Porosity parameter (S = 1.5, 2.5, 3.5, 4.5). It is clear that the velocity decreases with increasing Porosity parameter.

The velocity profile for different Grashof number (Gr = 0.0, 0.5, 1.0, 2.0) is shown through Fig.5. It is well known that the profile increases with the increasing Grashof number.

The velocity profile for different mass Grashof number (Gc = 0.0, 0.5, 1.0, 2.0) is shown through Fig.6. It shows that the velocity increases with the increasing mass Grashof number.

Fig.7 shows the velocity profile for different Hall parameter (M_1= 0.1, 0.5, 1.0, 2.0). It exhibits that the profile increases with the increasing Hall parameter.

The velocity profile for different Radiation Parameter (N = 0.1, 0.9, 2.5, 3.0) is shown in Fig.8. It clearly exhibits that the velocity increases with the increasing Radiation parameter.

Fig.9 exhibits the velocity profile for different Peclet number (Pe = 0.1, 1.56, 2.85, 3.50). It is observed that the velocity decrease with increasing Peclet number.

The temperature profiles have been studied and presented through Fig.10 to12. Fig.10 shows the temperature profile for different Radiation parameter (N = 0.1, 0.5, 1.0, 1.5) It is well known that temperature profile increases with increasing Radiation parameter.

The temperature profile for frequency of oscillation (w = 0.1, 0.5, 1.56, 2.0) is shown in Fig.11. It exhibits that the profile decreases with the increasing oscillating frequency.

The temperature profile for various Peclet number (Pe=1.15, 2.56, 3.86, 7.01) is shown in Fig.12. It is clear from the figure that with the increasing Peclet number the temperature profile decreases.

The concentration profiles have been studied and presented through Fig.13 and 15. Fig.13 exhibits the concentration profile for different Schmidt number (Sc = 0.85, 0.95, 1.35, 3.95). It is clear that the concentration decreases with the increasing Schmidt number.

The concentration profile for various Jump in temperature (J = 55.50, 85.50, 100.50, 123.50) is shown Fig.14. The concentration increases with increasing chemical reaction.

The concentration profile for various frequency of oscillations (w = 20.50, 19.50, 15.50, 10.5) is shown Fig.15. The concentration increases with increasing frequency of oscillations.

The shear stress for different mass Grashof number (Gc = 0.5, 1.0, 1.5, 2.0) is shown in Fig.16. The shear stress increases with increasing mass Grashof number.

Fig.17 shows the shear stress for different Hatrmann number (H = 2.5, 1.5, 1.0, 0.5). The shear stress decreases with increasing Hatrmann number.

The shear stress for different values of the Radiation parameter (N = 1.5, 1.35, 1.0, 0.5) is shown in Fig.18. The shear stress increases with increasing Radiation parameter.

The shear stress for different values of the Peclet number (Pe = 2.0, 1.0, 0.5, 0.0) is shown in Fig.19. The shear stress decreases with increasing Peclet number.

The shear stress for different porosity parameter (s = 1.55, 1.0, 0.5, 0.2)is shown in the Fig.20. The shear stress decreases with increasing porosity parameter.

The shear stress for different values of the Grashof number(Gr = 0.0, 0.5, 1.0, 2.0) is shown in theFig.21. The shear stress increases with increasing Grashof number.

The shear stress for different values of the Schmidt number(Sc = 4.0, 3.0, 2.0, 1.0) is shown in the Fig.22. The shear stress increases with increasing Schmidt number.

The rate of heat transfer for different values of the radiation parameter (N = 0.01, 0.20, 0.40, 0.50) is shown in Fig.23. The rate of heat transfer increases with increasing radiation parameter.

The rate of heat transfer for different values of Peclet number (Pe = 0.20, 0.10 ,0.05, 0.01) is shown in the Fig.24. The rate of heat transfer decreases with increasing Peclet number.

The rate of heat transfer for different values of the frequency of oscillation (w = 0.20, 0.10, 0.05, 0.01) is shown in the Fig. 25. The rate of heat transfer decreases with increasing frequency of oscillation.

The rate of mass transfer for different values of the jump in temperature (J = 0.1, 0.5, 1.0 , 2.0) is shown in Fig.26. The rate of mass transfer increases with increasing chemical reaction

The rate of mass transfer for different values of the Schmidt number (Sc = 0.1, 0.5, 3.0 , 1.0) is shown in Fig.27. The rate of mass transfer increases with increasing Schmidt number.

The rate of mass transfer for different values of frequency of oscillation (w = 0.1, 0.5, 1.0 , 2.0) is shown in Fig.28. The rate of mass transfer increases with increasing frequency of oscillation.

V. CONCLUSION

In this study exact solution for the velocity field, temperature and concentration in the presence of Hall current, magnetic field, porosity parameter, radiation parameter, slip parameter and jump in temperature are constructed. A uniform magnetic field is applied transversely to the flow. The solutions so obtained, depending on the initial and the boundary conditions are presented as sum of the steady state transient solutions. Graphical results shows the influence of the various non dimensional parameters which occurs in the problem under study. The following conclusions are made

i) Velocity increases with the increase in slip parameter, Schmidt number, Grashof number and Radiation parameter.
ii) Velocity decreases with the increase in Hartmann number, Porosity parameter, Hall parameter and Peclet number.
iii) Temperature increases with the increase in Radiation parameter and decreases with the increase in frequency of oscillation and Peclet number.
iv) Concentration increases with the increase in Jump in temperature and decreases with the increase in Schmidt number.
v) Shear stress increases with the increase in Grashof number and Radiation parameter decreases with the increases with the increase in Hartmann number, Peclet number and porosity parameter.
vi) Rate of heat transfer increases with the increase in Radiation parameter, decreases with the increase in Peclet number and frequency of oscillation.
vii) Rate of mass transfer increases with the increase in Jump in temperature, Schmidt number and frequency of oscillation.

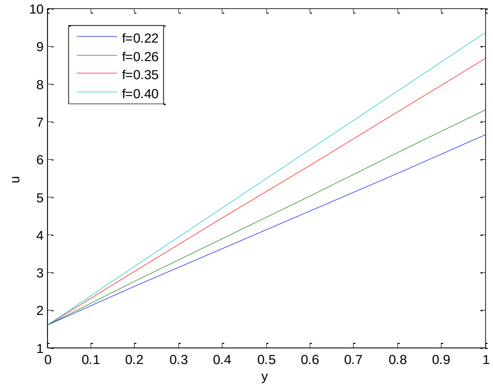

Fig.1: Velocity profile for various Slip parameter (γ)
[Re=2, s=1.5, H=1, Gr=1, Pe=2,N=2.5, λ =1, Sc=2, wt=11/7, J=2,w=1.5 ,Gc=1.5, M1=1, i=1.0]

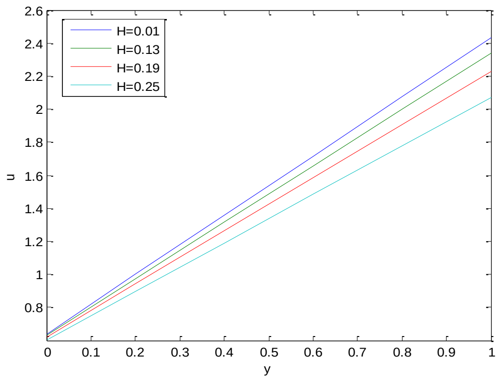

Fig. 2: Velocity profile for different Hartmann number (H)
[Re=2, s=1.5, γ =1, Gr=1.5,Pe=2, N=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gc=1.5, M1=1, i=1.0]

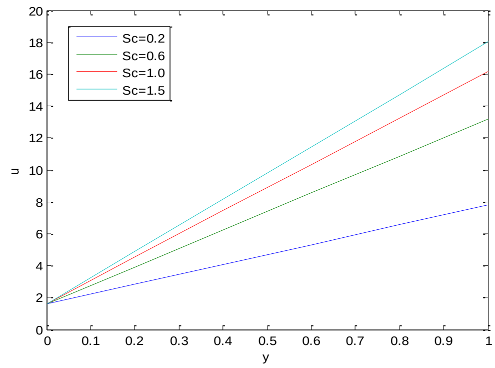

Fig.3: Velocity profile for different Schmidt number (Sc)
[Re=2, s=1.5, γ =1, Gr=1.5, Pe=2, N=2.5, λ =1, H=2, wt=11/7, J=2, w=1.5, Gc=1.5, M1=1, i=1.0]

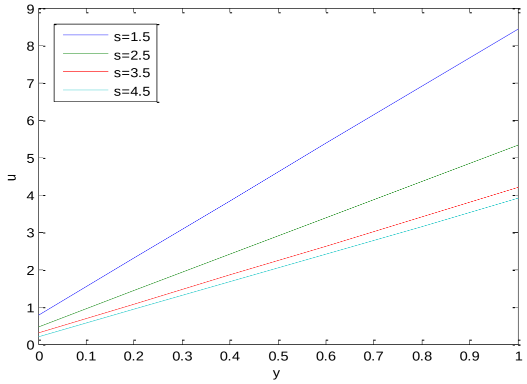

Fig.4: Velocity profile for different Porosity parameter(S) [Re=2, H=1.5, γ =1, Gr=1.5, Pe=2, N=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gc=1.5, M_1=1, i=1.0]

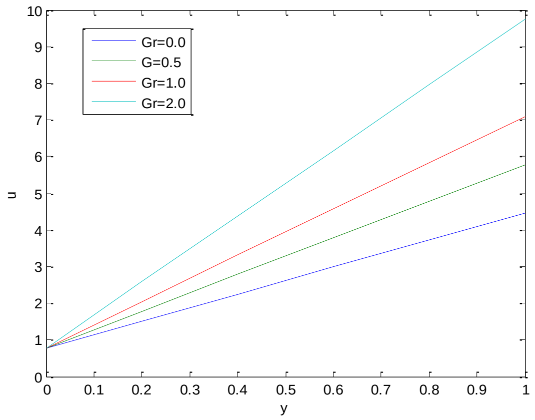

Fig.5: Velocity profile for different Grashof number (Gr) [Re=2, H=1.5, γ =1, s=1.5, Pe=2, N=2.5, λ =1, Sc=2, wt=11/7,J=2, w=1.5, Gc=1.5, M1=1, i=1.0]

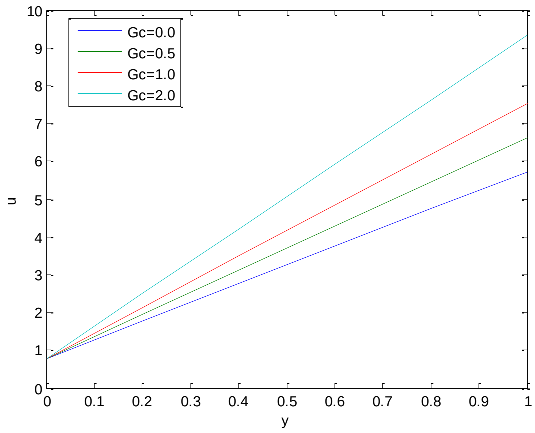

Fig.6: Velocity profile for different mass Grashof number (Gc) [Re=2, H=1.5, γ =1, s=1.5, Pe=2, N=2.5, λ =1, Sc=2, wt=11/7,J=2, w=1.5, Gr=1.5, M1=1, i=1.0]

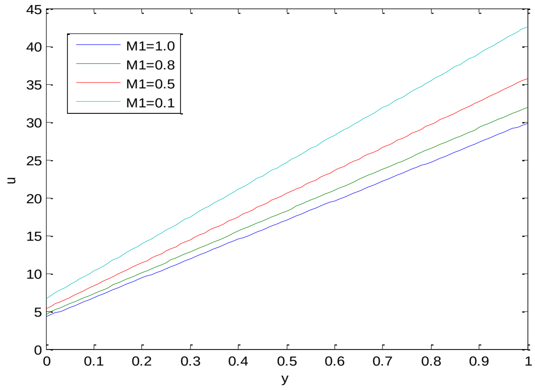

Fig.7: Velocity profile for different Hall parameter (M_1) [Re=2, H=1.5, γ =1, s=1.5,Gc=2, N=2.5, Sc=1.5, λ =1, wt=11/7, J=2.5, w=0.5, Gr=1.5, Pe=2.5,i=1.0]

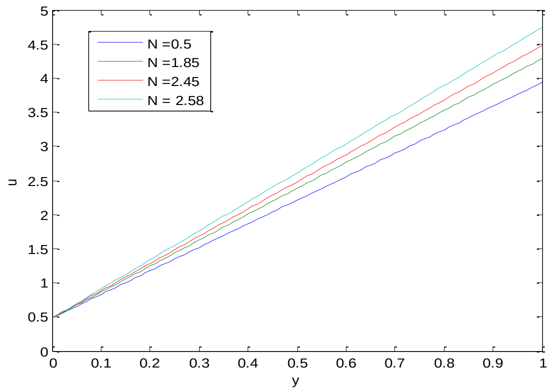

Fig.8: Velocity profile for different Radiation parameter (N)
[Re=2, H=1.5, γ =1, s=1.5, Gc=2, M1=2.5, Sc=2, wt=11/7, λ =1, J=2, w=1.5, Gr=1.5, Pe=1 ,i=1.0]

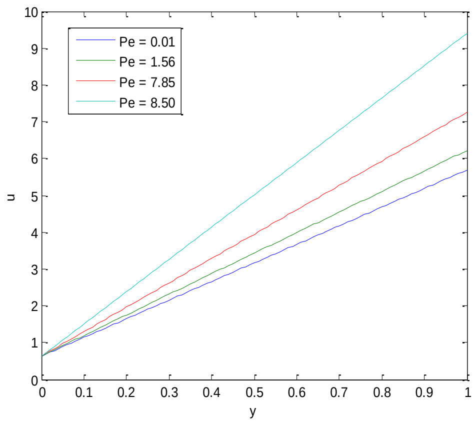

Fig.9: Velocity profile for various Peclet number (Pe) [Re=2, H=1.5, γ =1, s=1.5, Gc=2, N=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gr=1.5, M_1=1.5, i=1.0]

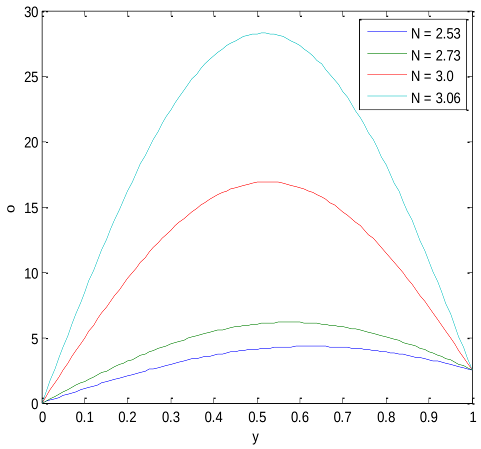

Fig.10: Temperature profile for various Radiation parameter (N) [Pe=0.5, w=0.2, i=0.5, wt=22/7]

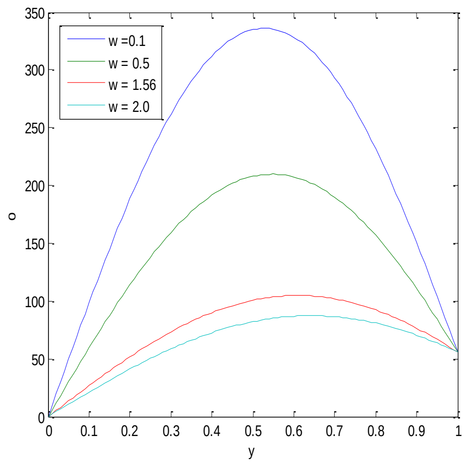

Fig.11:Temperature profile for various frequency of oscillation (w) [Pe=0.5, N=0.2, i=0.5, wt=22/7]

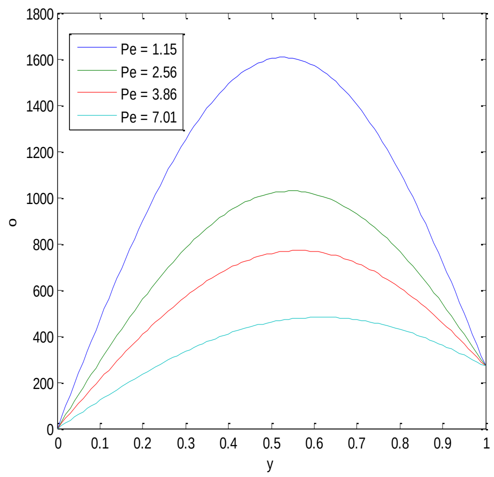

Fig.12:Temperature profile for various Peclet number (Pe) [w=0.5, N=0.2, i=0.5, wt=22/7]

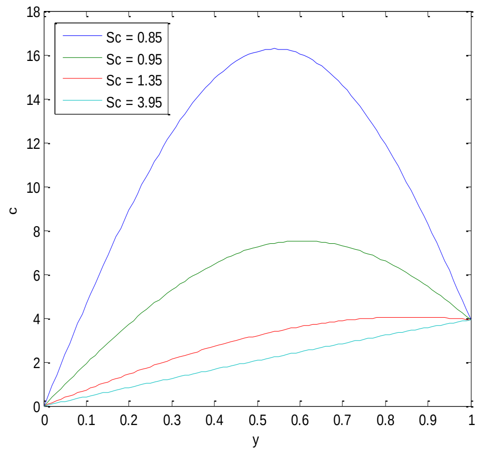

Fig.13: Concentration profile for various Schmidt number (Sc) [w=0.5, i=0.65, J=5.75, wt=11/7]

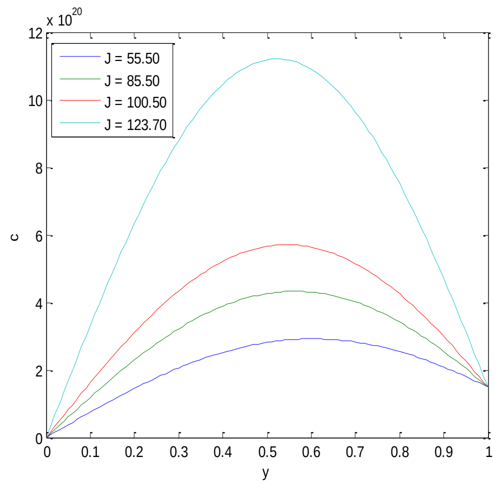

Fig.14: Concentration profile for various chemical reaction (J) [w=0.5, i=0.65, Sc=5.75, wt=11/7]

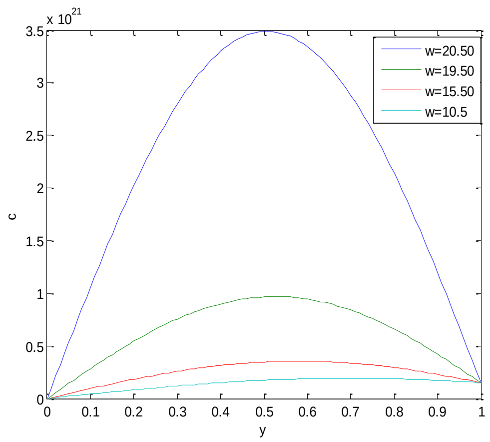

Fig.15: Concentration profile for various frequency of oscillation(w) [J=10, i=15, Sc=5.75, wt=22/7]

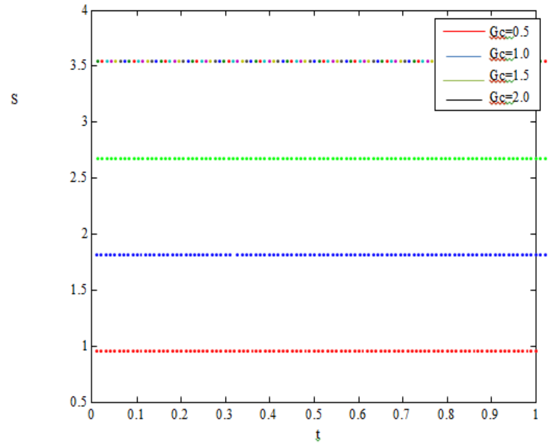

Fig.16:The shear stress for various mass Grashof number(Gc) [Re=2, N=1.5, γ =1, s=1.5, H=1.5, Pe=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gr=1.5, M_1=1, i=1.0]

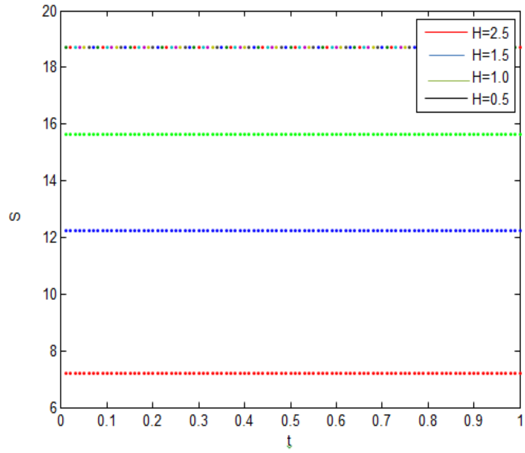

Fig.17: The shear stress for different Hatrmann number(H) [Re=2, N=1.5, γ =1, s=1.5, Gc=1.5, Pe=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gr=1.5, M_1=1,i =1.0]

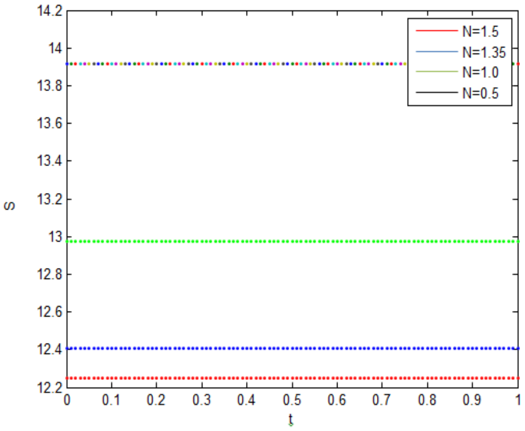

Fig.18: The shear stress for different Radiation parameter (N) [Re=2, H=1.5, γ =1, s=1.5, Gc=1.5, Pe=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gr=1.5, M_1=1, i =1.0]

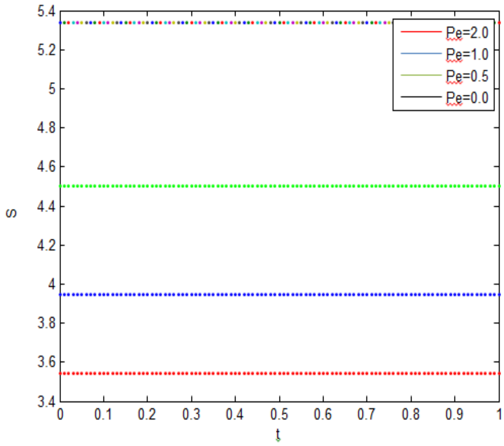

Fig.19: The shear stress for different Peclet number(Pe) [Re=2, H=1.5, γ =1, s=1.5, Gc=1.5, N=2.5, λ =1, Sc=2, wt=11/7,J=2, w=1.5, Gr=1.5, M_1=1, i=1.0]

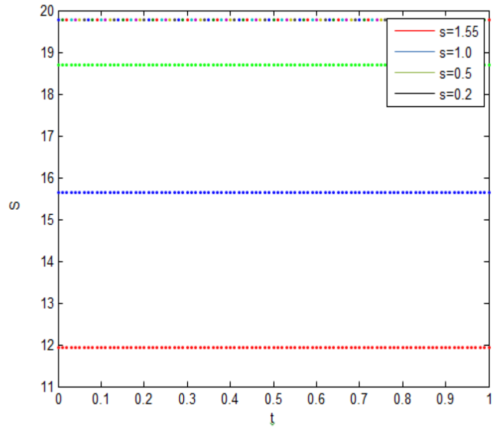

Fig.20: The shear stress for different values of porosity parameter(s) [Re=2, H=1.5, γ =1, Pe=1.5, Gc=1.5, N=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, Gr=1.5, M_1=1, i =1.0]

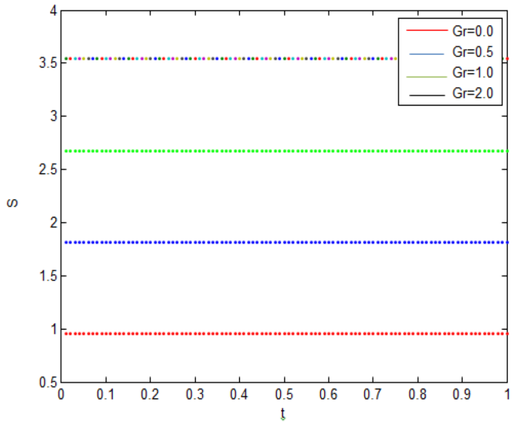

Fig 21:The shear stress for different values Grashof number(Gr) [Re=2, H=1.5, γ =1, Pe=1.5, Gc=1.5, N=2.5, λ =1, Sc=2, wt=11/7, J=2, w=1.5, s =1.5, M_1=1, i=1.0],

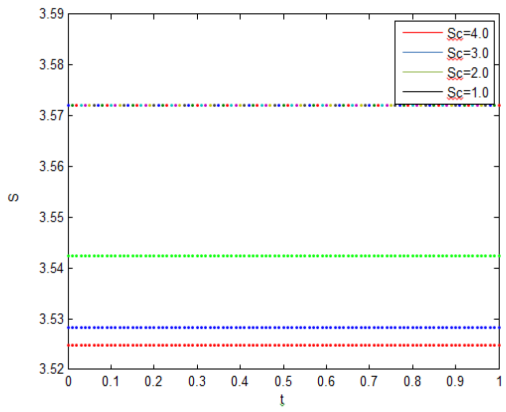

Fig.22: The shear stress for different values Schmidt number(Sc) [Re=2, H=1.5, γ =1, Pe=2, Gc=1.5, N=2.5, λ =1.5, Gr=2, wt=11/7, J=2, w=1.5, s =1.5, M_1=1, i=1.0]

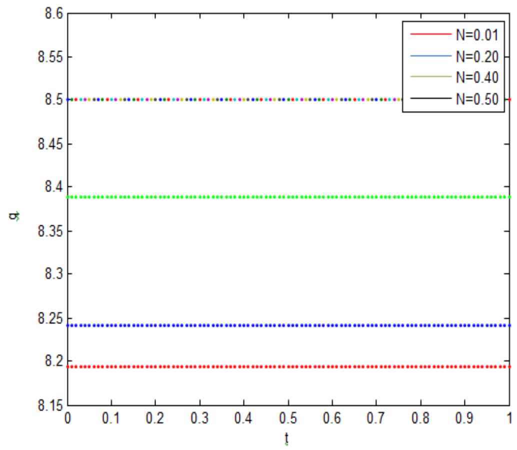

Fig.23: Rate of Heat transfer for different values Radiation parameter (N) [Pe=1.5, wt=11/7, w=1.5,i =1.0]

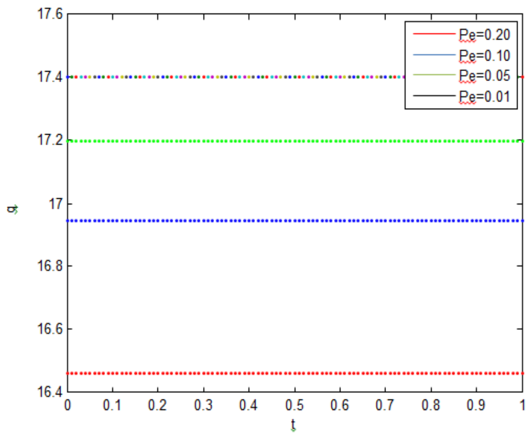

Fig.24: Rate of Heat transfer for different values of the Peclet number (Pe) [N=1.5, wt=11/7, w=1.5, i =1.0]

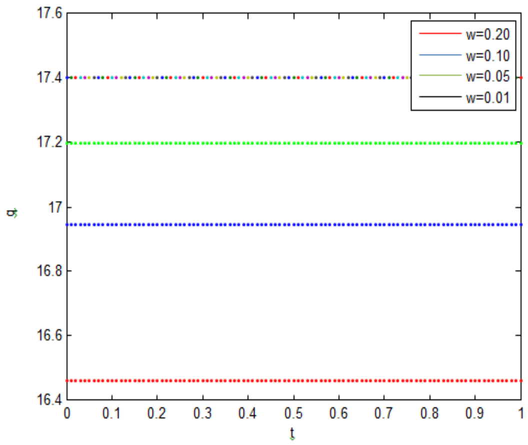

Fig.25: Rate of Heat transfer for different frequency oscillation (w) [N=1.5, wt=11/7, Pe=1.5, i =1.0]

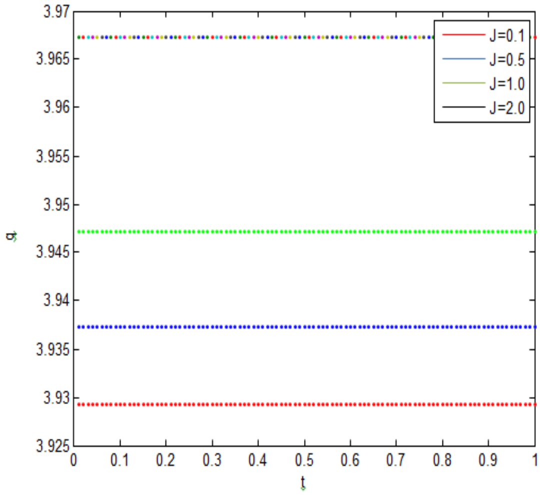

Fig.26: Rate of mass transfer for various values of chemical reaction (J) [w=0.5, i =0.65, Sc=5.75, wt=11/7]

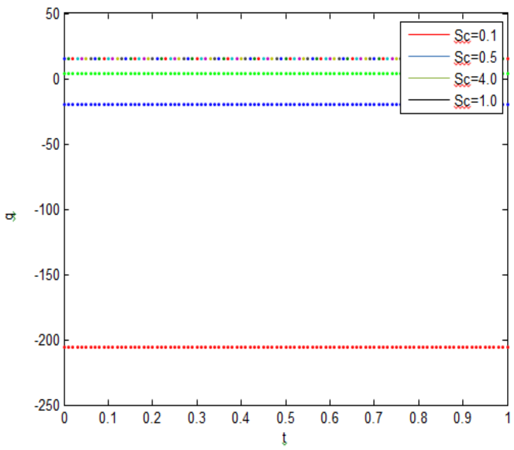

Fig.27: Rate of mass transfer for different Schmidt number (Sc) [w=0.5, i =0.65, J=5.75, wt=11/7]

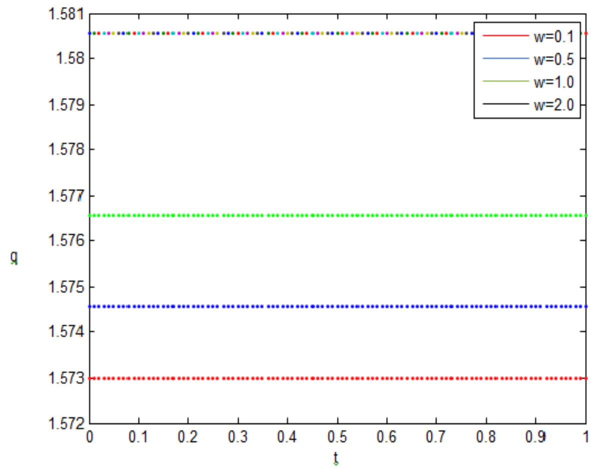

Fig.28: Rate of mass transfer for different frequency of oscillation (w) [J=0.5, i =0.65, Sc=5.75, wt=11/7]

REFERENCES

[1] Ram, Gulab and R.S. Mishra, Unsteady flow through MHD porous media, *Indian Journal of Pure Applied Mathematics 8(6)*, 1976, 637 – 647.

[2] A.A Raptis, Unsteady free convective flow and mass transfer through a porous medium bounded by an infinite limiting vertical surface with constant suction and time-dependent temperature, *International Journal of Engineering Research*, *7(4)*, 1983, 385–389.

[3] M.A. Mansour, R.A. Mohammed, M.M. Abd-Elaziz, and S.E. Ahmed, Fluctuating thermal and mass diffusion on unsteady MHD convection of a micro polar fluid through a porous medium past a vertical plate in slip-flow regime. *International Journal of Applied Mathematics and Mechanics 3*, 2010, 99-117.

[4] K. Anwar, MHD unsteady free convection flow past a vertical porous plate, *ZAMM - Journal of Applied Mathematics and Mechanics***,** *78(4)*, (1998), 255-270.

[5] K.D. Alagoa, G.Tay and T.M.Abbey, Radiative and free convective effects of a MHD flow through a porous medium between infinite parallel plates with time-dependent suction, *Astrophysics and Space Science,260(4),* 1998, 455–468.

[6] H.A. Attia, Unsteady MHD flow and heat transfer of dusty fluid between parallel plates with variable physical properties, *Applied Mathematical Modelling, 26* , 2002, 863–875.

[7] R.M.V Murthy, G. Noushima Humera, and R.M. Chenna Krishna Reddy, MHD Unsteady free convective Walter's memory flow with constant suction and heat Sink, *ARPN Journal of Engineering and Applied Sciences. 2(5)*, 2007, 12 – 16.

[8] L. HariKrishna, K. JagadeeswaraPillai, Hall Current effects on unsteady free convection flow past an infinite vertical plate with constant suction and heat sink, *International Review of Pure and Applied Mathematics(January-June), 6(1),* 2010, 11-21.

[9] F. Soltani, and U. Yilmazer, Slip velocity and slip layer thickness in flow of concentrated suspensions, *Journal of Applied Polymer Science, 70* (1998), 515-522.

[10] K. Watanebe, Yanuar; and H. Mizunuma, Slip of Newtonian fluids at solid boundary, *Japan Society of Mechanical Engineering, International Journal Series,B41*, 1998, 525.

[11] K.D. Singh and Rakesh kumar, Fluctuating Heat and Mass Transfer on Unsteady MHD Free Convection Flow of Radiating and Reacting Fluid past a Vertical Porous Plate in Slip- Flow Regime, ***J****ournal of* ***A****pplied* ***F****luid* ***M****echanics, 4(2)*, 2011, 101-106.

[12] A.R.A. Khaled and K. Vafai, The effect of the slip condition on stokes and Couette flows due to an oscillatory wall; exact solutions. *International Journal of Nonlinear Mechanic , 39*, 2004, 795-809

[13] O.D. Makinde, and P.Y. Mhone, Heat transfer MHD oscillatory flow in a channel filled with porous medium, *Rom Journal of Physics, 50(9-10)* 2005, Pp. 931-938.

[14] H. Zaman, Hall effects on the unsteady incompressible MHD fluid flow with slip conditions and porous walls, *Applied Mathematics and Physics, 1(2)*, 2013, 31-38.

[15] S. L. Gorelov and M. N. Kogan, Solution of the temperature jump (Knudsen layer flow) and linear heat-transfer problems for two parallel plates in a rarefied gas, *Fluid Dynamics*, *4(4)*, 1969, 72–76

[16] J.C.T. Wang, Effects of velocity slip and temperature jump on the boundary layer flow and heat transfer over a wedge, 6th *AIAA Theoretical Fluid Mechanics Conference* 27 - 30 June 2011, Honolulu, Hawaii.

[17] Odelu Ojjela and N. Naresh Kumar, Unsteady Heat and Mass Transfer of Chemically Reacting Micropolar Fluid in a Porous Channel with Hall and Ion Slip Currents, *International Scholarly Research Notices, 2014*, (2014), Article ID 646957, 11 pages.

[18] J.C. Misra and S.D. Adhikary, MHD oscillatory channel flow, heat and mass transfer in a physiological fluid in presence of chemical reaction, *Alexandria Engineering Journal, 55*, 2016, 287-297.

International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

R.Panneerselvi . "Hall Effect on Unsteady Heat and Mass Transfer Oscillatory Flow through Porous Medium under Slip Condition." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 9, 2017, pp. 48–58