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Viscous Dissipation and Mass Transfer Effects on MHD Oscillatory Flow in a Vertical Channel with Porous Medium

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Abstract

The present work investigate the effects of viscous dissipation and mass transfer on unsteady MHD oscillatory flow of an viscous fluid between two vertical parallel plates with porous medium and non- uniform wall temperatures. For an oscillatory time-dependent coupled non-linear equations involved in the present analysis are solved for the fluid velocity, temperature and concentration by perturbation technique. The effects of various parameters on the velocity, temperature and concentration profiles are shown graphically and discussed.

Keywords: Viscous Dissipation, Oscillatory flow, Chemical reaction, MHD, Porous Medium.

1. INTRODUCTION

The applications of oscillatory (or transient) flow of Newtonian and non-Newtonian fluids in channels with heat and mass transfer effect has its importance in many areas such as biological and industrial processes.

Nomenclature

B_0	Strength of applied magnetic field, kg/s^{2}A	S_c	Schmidt number
C	Dimensionless concentration	T	Fluid temperature, K
C_p	Specific heat at constant pressure, J/kgK	t	Time, s

D	Chemical molecular diffusivity, m^2/s
D_1	Rate of chemical reaction
Ec	Eckert number
Gc	Solutal Grashof number
Gr	Thermal Grashof number
g	Acceleration due to gravity, m/s^2
h	Distance between the plates, m
K	Permeability of porous medium, m^2
Kr	Chemical reaction parameter
κ	Thermal conductivity, W/mK
M	Magnetic parameter
Pr	Prandtl number
Q_0	Heat absorption parameter
q	Heat flux, W/m^2
R	Radiation parameter
S	Heat source parameter
U_0	Mean flow velocity, m/s
u	Dimensionless velocity, m/s
u_p	Wall dimensionless velocity

Greek Symbols

α	Mean radiation absorption coefficient
β	Thermal expansion coefficient, K^{-1}
β^*	Solutal expansion coefficient, K^{-1}
θ	Dimensionless temperature
μ	Dynamic viscosity, Kg/ms
σ	Stefan – Boltzmann constant
ρ	Density, Kg/m^3
υ	Kinematic viscosity, m^2/s
ω	Frequency of the oscillation

E.g. the quasi-periodic blood flow in the cardiovascular system can be described by the frequency components of the pressure and flow rate pulses, and many vascular diseases are associated with disturbances of the local flow conditions in the blood vessels. Several excellent studies have been presented concerning oscillatory hydro-magnetic flows for various geometrical situations including channels. Ahmed et al. [1] studied the numerical analysis for MHD radiating heat/mass transport in a Darcian porous regime bounded by an oscillating vertical surface. Balamurugan et al. [2] presented the unsteady MHD free convective flow past a moving vertical plate with time dependent suction and chemical reaction in a slip flow regime. Chand et al. [3] have obtained the analytical solutions for oscillatory free convective flow of viscous fluid through porous medium in a rotating vertical channel. Cogley et al. [4] analyzed the differential approximation for radiative heat transfer in a non-linear equation grey gas near equilibrium. El-Hakien and Hamza [5, 6, 7] studied an MHD oscillatory flow on free convection radiation through a porous medium. Ibrahim et al. [8] discussed the effect of the chemical reaction and radiation absorption on the unsteady MHD free convection flow past a semi–infinite vertical permeable moving plate with heat source and suction. The heat and mass transfer effects on MHD oscillatory flow in a channel filled with porous medium analyzed by Ibrahim and Makinde [9, 11]. Kataria and Patel [10] have examined the effects of radiation and chemical reaction on MHD Casson fluid flow past an oscillating vertical plate embedded in porous medium. Malapati and Polarapu [12] examined the unsteady MHD free convective heat and mass transfer in a boundary layer flow past a vertical permeable plate with thermal radiation and chemical reaction. The fluid property has a great influence on viscous dissipation because variation in fluid viscosity due to temperature may affect the flow characteristics. Viscous dissipation plays an important role in various areas such as food processing, polymer manufacturing, geological processes in fluids contained in various bodies, and many others. Mansour et al. [13] studied the effects of chemical reaction and viscous dissipation on MHD natural convection flows saturated in porous media. Some authors [14, 15, 16, 19] investigated an MHD oscillatory channel flow, heat and mass transfer in a channel in presence of chemical reaction and heat flux. Heat and mass transfer effects on MHD free convective flow through porous medium in the presence of radiation and viscous dissipation was carried out by Prasad and Salawu [17, 18]. Sharma et al. [20] analyzed radiative and free convective effects on MHD flow through a porous medium with periodic wall temperature and heat generation or absorption.

2. FORMULATION OF THE PROBLEM

We consider the unsteady magneto-hydrodynamics oscillatory flow of an incompressible, viscous dissipative, optically thin radiating and heat absorbing fluid between two infinite vertical parallel plates. The x^* - axis is taken along the vertical plates in upward direction, the y^* - axis is perpendicular to the wall of the channel and the transverse magnetic field of uniform strength B_0 is applied in a direction parallel to the y^* - axis, as shown in Fig. 1. The plate at $y^* = 0$ is oscillating in its own plane, while the other plate at $y^* = h$ is moving with a constant velocity u_p^* in the x^* direction. It is assumed that the temperature and the concentration at the wall $y^* = 0$ are oscillating, while T_1^* and C_1^* are constant temperature and concentration at $y^* = h$. Under these assumptions, the unsteady flow is governed by the following system of partial differential equations

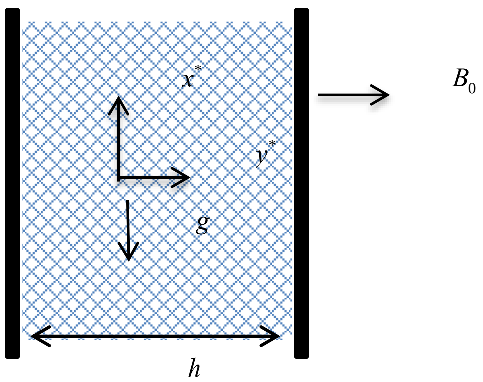

Fig. 1 Physical model and coordinate system

$$\frac{\partial u^*}{\partial t^*} = \upsilon \frac{\partial^2 u^*}{\partial y^{*2}} - \frac{\upsilon}{K^*} u^* - \frac{\sigma B_0^2}{\rho} u^* + g\beta\left(T^* - T_0^*\right) + g\beta^*\left(C^* - C_0^*\right) \tag{1}$$

$$\frac{\partial T^*}{\partial t^*} = \frac{\kappa}{\rho c_p}\frac{\partial^2 T^*}{\partial y^{*2}} - \frac{1}{\rho c_p}\frac{\partial q}{\partial y^*} - \frac{Q_0}{\rho c_p}(T^* - T_0^*) + \frac{\upsilon}{c_p}\left(\frac{\partial u^*}{\partial y^*}\right)^2 \tag{2}$$

$$\frac{\partial C^*}{\partial t^*} = D\frac{\partial^2 C^*}{\partial y^{*2}} - D_1\left(C^* - C_0^*\right) \tag{3}$$

The relevant boundary conditions in non-dimensional form are given by

$$\left.\begin{array}{llll} u^* = U_0(1+\varepsilon e^{i\omega^* t}), & T^* = T_1^* + \varepsilon(T_1^* - T_0^*)e^{i\omega^* t}, & C^* = C_1^* + \varepsilon(C_1^* - C_0^*)e^{i\omega^* t} & at \quad y^* = 0 \\ u^* = u_p^*, & T^* = T_1^*, & C^* = C_1^* & at \quad y^* = h \end{array}\right\} \tag{4}$$

Here ε are scalar constants which are less than unity (i.e. $\varepsilon << 1$). We assume that the fluid is optically thin with a relativity low density and radiative heat flux is according to the Ref [4] is given by

$$\frac{\partial q}{\partial y^*} = 4\alpha^2(T^* - T_0^*) \tag{5}$$

Introducing the following non-dimensional quantities

$$y = \frac{y^*}{h},\ t = \frac{t^*\upsilon}{h^2},\ \omega = \frac{h^2\omega^*}{\upsilon},\ u = \frac{u^*}{U_0},\ \theta = \frac{T^* - T_0^*}{T_1^* - T_0^*},\ C = \frac{C^* - C_0^*}{C_1^* - C_0^*},\ u_p = \frac{u_p^*}{U_0},$$
$$Gr = \frac{g\beta h^2(T_1^* - T_0^*)}{\upsilon U_0},\ Gc = \frac{g\beta^* h^2(C_1^* - C_0^*)}{\upsilon U_0},\ M^2 = \frac{\sigma B_0^2 h^2}{\rho\upsilon},\ R^2 = \frac{4\alpha^2 h^2}{\kappa},$$
$$Ec = \frac{U_0^2}{c_p(T_1^* - T_0^*)},\ K^2 = \frac{h^2}{K^*},\ S = \frac{Q_0 h^2}{\kappa},\ \Pr = \frac{\rho\upsilon c_p}{\kappa},\ Sc = \frac{\upsilon}{D},\ Kr = \frac{D_1 h^2}{\upsilon} \tag{6}$$

Using Eq. (6), the governing Eqs. (1) – (4) are converted to the non-dimensional form as follows

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} - (K^2 + M^2)u + Gr\theta + GcC \tag{7}$$

$$\Pr\frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2} - (R^2 + S)\theta + \Pr Ec\left(\frac{\partial u}{\partial y}\right)^2 \tag{8}$$

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

The associated boundary conditions are

$$\left.\begin{array}{llll} u = 1+\varepsilon e^{i\omega t}, & \theta = 1+\varepsilon e^{i\omega t}, & C = 1+\varepsilon e^{i\omega t} & at \quad y = 0 \\ u = u_p, & \theta = 1, & C = 1 & at \quad y = 1 \end{array}\right\} \tag{10}$$

3. SOLUTION OF THE PROBLEM

Eqs. (7) – (10) are coupled, non-linear partial differential equations and these cannot be solved in closed form. However, these equations can be reduced to a set of ordinary differential equations, which can be solved analytically. This can be done by representing the velocity, temperature and concentration of the fluid such as

$$\left.\begin{aligned} u(y,t) &= u_0(y) + \varepsilon e^{i\omega t} u_1(y) + o(\varepsilon^2) \\ \theta(y,t) &= \theta_0(y) + \varepsilon e^{i\omega t} \theta_1(y) + o(\varepsilon^2) \\ C(y,t) &= C_0(y) + \varepsilon e^{i\omega t} C_1(y) + o(\varepsilon^2) \end{aligned}\right\} \tag{11}$$

After substituting Eqs. (11) into Eqs. (7) – (10), neglecting the higher order terms of $O(\varepsilon^2)$, and the following equations are obtained

$$u_0'' - \left(K^2 + M^2\right) u_0 = -Gr\theta_0 - GcC_0 \tag{12}$$

$$u_1'' - \left(K^2 + M^2 + i\omega\right) u_1 = -Gr\theta_1 - GcC_1 \tag{13}$$

$$\theta_0'' - \left(R^2 + S\right)\theta_0 = -\Pr Ec\, u_0'^2 \tag{14}$$

$$\theta_1'' - \left(R^2 + S + i\omega \Pr\right)\theta_1 = -2\Pr Ec\, u_0' u_1' \tag{15}$$

$$C_0'' - Kr\, Sc\, C_0 = 0 \tag{16}$$

$$C_1'' - (i\omega Sc + Kr\, Sc)\, C_1 = 0 \tag{17}$$

With the corresponding boundary conditions are

$$\left.\begin{aligned} &u_0 = 1,\ u_1 = 1,\ \theta_0 = 1, \theta_1 = 1,\ C_0 = 1,\ C_1 = 1 \quad at \quad y = 0 \\ &u_0 = u_p, u_1 = 0,\ \theta_0 = 1, \theta_1 = 0, C_0 = 1, C_1 = 0 \quad at \quad y = 1 \end{aligned}\right\} \tag{18}$$

Still Eqs. (12) - (15) are coupled and non-linear, whose exact solutions are not possible. Therefore, we apply another perturbation scheme for Eckert number $Ec << 1$ as

$$\left.\begin{aligned} u_0(y) &= u_{01}(y) + Ecu_{02}(y) + Ec^2 u_{03}(y) \\ u_1(y) &= u_{11}(y) + Ecu_{12}(y) + Ec^2 u_{13}(y) \\ \theta_0(y) &= \theta_{01}(y) + Ec\theta_{02}(y) + Ec^2\theta_{03}(y) \\ \theta_1(y) &= \theta_{11}(y) + Ec\theta_{12}(y) + Ec^2\theta_{13}(y) \end{aligned}\right\} \tag{19}$$

and comparing the coefficients of Ec^0 and Ec^1, then we get the following equations

$$u_{01}'' - \left(K^2 + M^2\right) u_{01} = -Gr\theta_{01} - GmC_0 \tag{20}$$

$$u_{11}'' - \left(K^2 + M^2 + i\omega\right) u_{11} = -Gr\theta_{11} - GcC_1 \tag{21}$$

$$\theta_{01}'' - \left(R^2 + S\right)\theta_{01} = 0 \tag{22}$$

$$\theta_{11}'' - \left(R^2 + S + i\omega \Pr\right)\theta_{11} = 0 \tag{23}$$

$$u_{02}'' - \left(K^2 + M^2\right) u_{02} = -Gr\theta_{02} \tag{24}$$

$$u_{12}'' - \left(K^2 + M^2 + i\omega\right) u_{12} = -Gr\theta_{12} \tag{25}$$

$$\theta_{02}'' - \left(R^2 + S\right)\theta_{02} = -\Pr u_{01}'^2 \tag{26}$$

$$\theta_{12}'' - \left(R^2 + S + i\omega \Pr\right)\theta_{12} = -2\Pr u_{01}' u_{11}' \tag{27}$$

along with the respective boundary conditions

$$\left.\begin{array}{l} u_{01} = 1,\ u_{02} = 0,\ u_{11} = 1, u_{12} = 0, \theta_{01} = 1, \theta_{02} = 0, \theta_{11} = 1, \theta_{12} = 0, C_0 = 1,\ C_1 = 1 \quad at \quad y = 0 \\ u_{01} = u_p, u_{02} = 0, u_{11} = 0, u_{12} = 0, \theta_{01} = 1, \theta_{02} = 0, \theta_{11} = 0, \theta_{12} = 0, C_0 = 1,\ C_1 = 0 \quad at \quad y = 0 \end{array}\right\} \tag{28}$$

Solving Eqs. (20) to (27) under the boundary conditions in Eq. (28), we obtain the solutions for concentration, velocity and temperature distribution as

$$\begin{aligned} u(y,t) = {} & A_7 e^{B_3 y} + A_8 e^{-B_3 y} + B_5 (A_5 e^{B_2 y} + A_6 e^{-B_2 y}) + B_6 (A_1 e^{B_4 y} + A_2 e^{-B_4 y}) + Ec[A_{11} e^{B_3 y} + A_{12} e^{-B_3 y} - Gr\{B_{29} e^{B_2 y} + \\ & B_{30} e^{-B_2 y} - \Pr(B_{31} e^{2B_3 y} + B_{32} e^{-2B_3 y} + B_{33} e^{2B_2 y} + B_{34} e^{-2B_2 y} + B_{35} e^{2B_4 y} + B_{36} e^{-2B_4 y} + B_{37} e^{(B_2+B_3)y} + B_{38} e^{(B_3-B_2)y} \\ & + B_{39} e^{(B_3+B_4)y} + B_{40} e^{(B_3-B_4)y} + B_{41} e^{(B_2-B_3)y} + B_{42} e^{-(B_3+B_2)y} + B_{43} e^{(B_4-B_3)y} + B_{44} e^{-(B_4+B_3)y} + B_{45} e^{(B_2+B_4)y} + B_{46} \\ & e^{(B_2-B_4)y} + B_{47} e^{(B_4-B_2)y} + B_{48} e^{-(B_2+B_4)y} + B_{49})\}] + \varepsilon e^{i\omega t}[A_{15} e^{B_{53} y} + A_{16} e^{-B_{53} y} + B_{54} (A_{13} e^{B_{52} y} + A_{14} e^{-B_{52} y}) + B_{55} \\ & \left(A_3 e^{B_1 y} + A_4 e^{-B_1 y}\right) + Ec\{A_{19} e^{B_{53} y} + A_{20} e^{-B_{53} y} + B_{94} e^{B_{52} y} + B_{95} e^{-B_{52} y} + 2\Pr Gr(B_{96} e^{(B_3+B_{53})y} + B_{97} e^{(B_3-B_{53})y} + \\ & B_{98} e^{(B_3+B_{52})y} + B_{99} e^{(B_3-B_{52})y} + B_{100} e^{(B_1+B_3)y} + B_{101} e^{(B_3-B_1)y} + B_{102} e^{(B_{53}-B_3)y} + B_{103} e^{-(B_{53}+B_3)y} + B_{104} e^{(B_{52}-B_3)y} + B_{105} \\ & e^{-(B_{52}+B_3)y} + B_{106} e^{(B_1-B_3)y} + B_{107} e^{-(B_1+B_3)y} + B_{108} e^{(B_2+B_{53})y} + B_{109} e^{(B_2-B_{53})y} + B_{110} e^{(B_2+B_{52})y} + B_{111} e^{(B_2-B_{52})y} + B_{112} \\ & e^{(B_1+B_2)y} + B_{113} e^{(B_2-B_1)y} + B_{114} e^{(B_{53}-B_2)y} + B_{115} e^{-(B_2+B_{53})y} + B_{116} e^{(B_{52}-B_2)y} + B_{117} e^{-(B_2+B_{52})y} + B_{118} e^{(B_1-B_2)y} + B_{119} \\ & e^{-(B_1+B_2)y} + B_{120} e^{(B_4+B_{53})y} + B_{121} e^{(B_4-B_{53})y} + B_{122} e^{(B_{52}+B_4)y} + B_{123} e^{(B_4-B_{52})y} + B_{124} e^{(B_1+B_4)y} + B_{125} e^{(B_4-B_1)y} + B_{126} \\ & e^{(B_{53}-B_4)y} + B_{127} e^{-(B_4+B_{53})y} + B_{128} e^{(B_{52}-B_4)y} + B_{129} e^{-(B_4+B_3)y} + B_{130} e^{(B_1-B_4)y} + B_{131} e^{-(B_1+B_4)y})\}] \end{aligned}$$

$$\begin{aligned} \theta(y,t) = {} & A_5 e^{B_2 y} + A_6 e^{-B_2 y} + Ec[A_9 e^{B_2 y} + A_{10} e^{-B_2 y} - \Pr(B_8 e^{2B_3 y} + B_9 e^{-2B_3 y} + B_{10} e^{2B_2 y} + B_{11} e^{-2B_2 y} + B_{12} e^{2B_4 y} + B_{13} e^{-2B_4 y} \\ & + B_{14} e^{(B_2+B_3)y} + B_{15} e^{(B_3-B_2)y} + B_{16} e^{(B_3+B_4)y} + B_{17} e^{(B_3-B_4)y} + B_{18} e^{(B_2-B_3)y} + B_{19} e^{-(B_3+B_2)y} + B_{20} e^{(B_4-B_3)y} + B_{21} e^{-(B_4+B_3)y} \\ & + B_{22} e^{(B_2+B_4)y} + B_{23} e^{(B_2-B_4)y} + B_{24} e^{(B_4-B_2)y} + B_{25} e^{-(B_2+B_4)y} + B_{26})] + \varepsilon e^{i\omega t}[A_{13} e^{B_{52} y} + A_{14} e^{-B_{52} y} + Ec\{A_{17} e^{B_{52} y} + A_{18} \\ & e^{-B_{52} y} - 2\Pr(B_{57} e^{(B_3+B_{53})y} + B_{58} e^{(B_3-B_{53})y} + B_{59} e^{(B_3+B_{52})y} + B_{60} e^{(B_3-B_{52})y} + B_{61} e^{(B_1+B_3)y} + B_{62} e^{(B_3-B_1)y} + B_{63} e^{(B_{53}-B_3)y} + \\ & B_{64} e^{-(B_{53}+B_3)y} + B_{65} e^{(B_{52}-B_3)y} + B_{66} e^{-(B_{52}+B_3)y} + B_{67} e^{(B_1-B_3)y} + B_{68} e^{-(B_1+B_3)y} + B_{69} e^{(B_2+B_{53})y} + B_{70} e^{(B_2-B_{53})y} + B_{71} e^{(B_2+B_{52})y} \\ & + B_{72} e^{(B_2-B_{52})y} + B_{73} e^{(B_1+B_2)y} + B_{74} e^{(B_2-B_1)y} + B_{75} e^{(B_{53}-B_2)y} + B_{76} e^{-(B_2+B_{53})y} + B_{77} e^{(B_{52}-B_2)y} + B_{78} e^{-(B_2+B_{52})y} + B_{79} e^{(B_1-B_2)y} \\ & + B_{80} e^{-(B_1+B_2)y} + B_{81} e^{(B_4+B_{53})y} + B_{82} e^{(B_4-B_{53})y} + B_{83} e^{(B_{52}+B_4)y} + B_{84} e^{(B_4-B_{52})y} + B_{85} e^{(B_1+B_4)y} + B_{86} e^{(B_4-B_1)y} + B_{87} e^{(B_{53}-B_4)y} \\ & + B_{88} e^{-(B_4+B_{53})y} + B_{89} e^{(B_{52}-B_4)y} + B_{90} e^{-(B_4+B_3)y} + B_{91} e^{(B_1-B_4)y} + B_{92} e^{-(B_1+B_4)y})\}] \end{aligned}$$

$$C(y,t) = A_1 e^{B_4 y} + A_2 e^{-B_4 y} + \varepsilon e^{i\omega t}\left(A_3 e^{B_1 y} + A_4 e^{-B_1 y}\right)$$

4. RESULTS AND DISCUSSIONS

We have presented the non-dimensional fluid velocity, fluid temperature and concentration for several values of magnetic parameter M, Eckert number Ec, thermal Grashof number Gr, Grashof number for mass transfer Gc, permeability of porous medium K, radiation parameter R, heat source parameter S, chemical reaction parameter Kr, Schmidt number Figs. 2–15. All the numerical calculations are to be carried out for $M=1,\ U_p=0.5, K=0.3, R=0.5,\ \varepsilon=0.001, t=1,\ \omega=0.5,\ S=2,$ $\Pr=0.71, Gr=4, Gc=2, Kr=2, Sc=0.5$ throughout the problem. The variation of the fluid velocity and temperature profile for different values of viscous dissipation parameter (i.e. Eckert number Ec) are plotted in Fig. 2 and 3. It is seen that the Eckert number increases, then the velocity profile decreases and the temperature of the fluid increases. Physically, the viscosity of the fluid will take energy from the motion of the fluid and transform it into internal energy of the fluid.

Fig. 4 and 5 describe respectively the behaviors of the velocity and temperature profile for different values of radiation parameter R and it is noticed that an increase in radiation parameter results in decrease of velocity and temperature profile.

Figs. 6 and 7 illustrate the effect of heat source parameter S on the velocity and temperature profiles. An increase in the heat source parameter reduces the velocity and temperature profiles. Physically, there is a tendency to reduce the temperature of the fluid in the presence of heat absorption (thermal sink) effect, it reduces the effect of thermal buoyancy, thereby reducing the fluid velocity.

Figs. 8 and 9 display the effects of thermal Grashof number Gr and solutal Grashof number Gc on the velocity profile. It is seen that the velocity increase on increasing thermal and concentration Grashof number. It is found that an increase in the thermal Grashof number results to rise in the values of velocity due to enhancement in buoyancy force. Here the positive values of the thermal Grashof number correspond to cooling of the surface.

It is noticed from Fig. 10 that the velocity profile decrease on increasing values of magnetic parameter M. This is due to the application of transverse magnetic field, which in turn acts as a Lorentz force that retards the flow. Fig. 11 shows that, the velocity profile decreases when the value of the permeable parameter K increases.

For different values of the chemical reaction parameter Kr, the velocity and concentration profile are plotted in Figs. 12 and 13. From figures it is found that velocity is decreasing by increasing the value of chemical reaction parameter.

After increasing the Schmidt number Sc, the velocity and concentration profile decreases. This causes the concentration buoyancy effects to decrease yielding a reduction in the fluid velocity. These behaviors are clearly shown in Figs. 14 and 15.

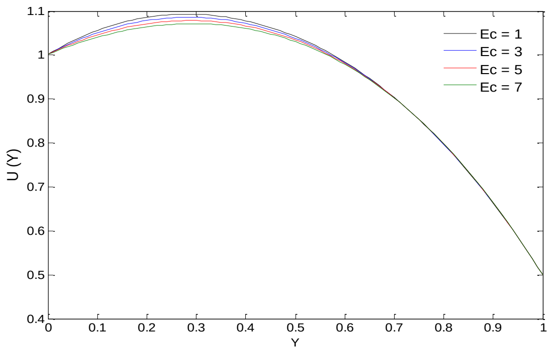

Fig. 2 Variation of Ec on velocity profile

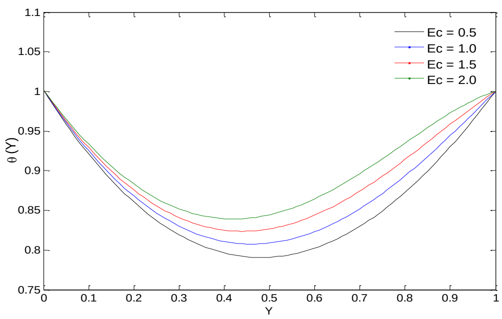

Fig. 3 Variation of Ec on temperature profile

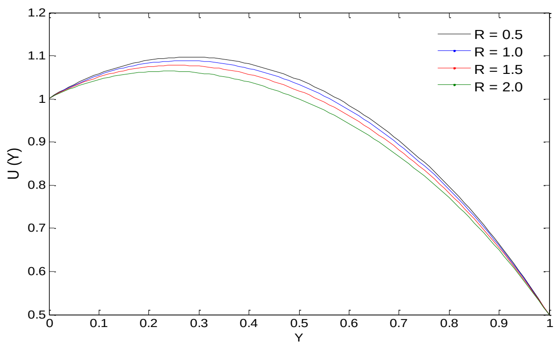

Fig. 4 Variation of R on velocity fprofile

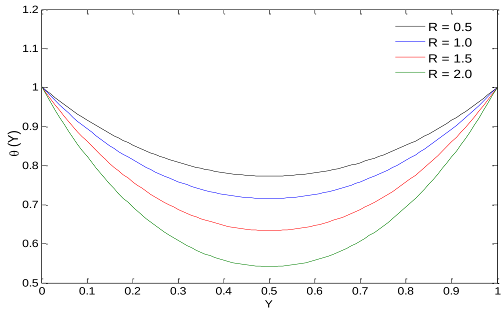

Fig. 5 Variation of R on temperature profile

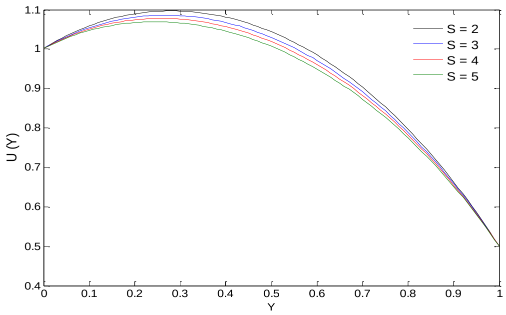

Fig. 6 Variation of S on velocity profile

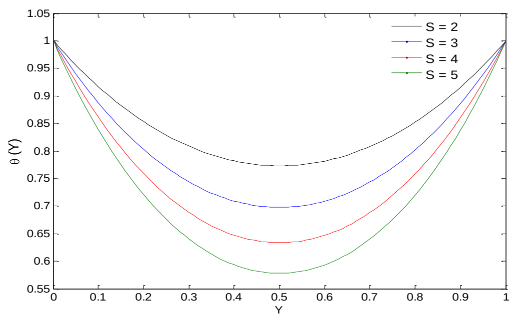

Fig. 7 Variation of S on temperature profile

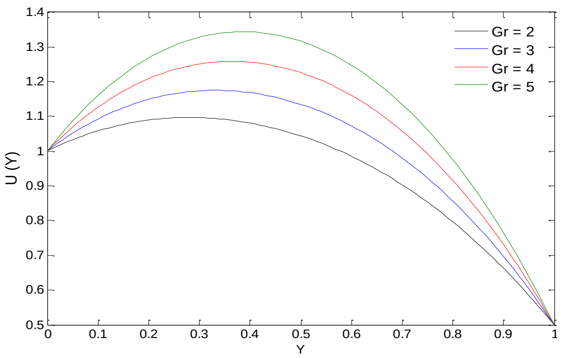

Fig. 8 Variation of Gr on velocity profile

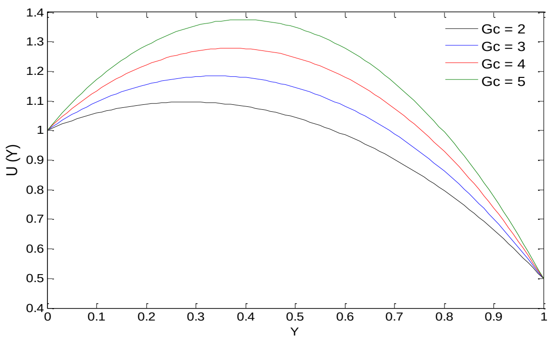

Fig. 9 Variation of Gc on velocity profile

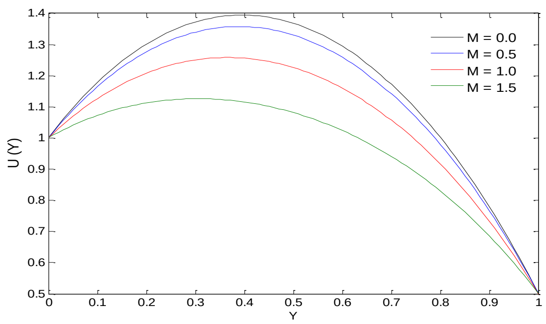

Fig. 10 Variation of M on velocity profile

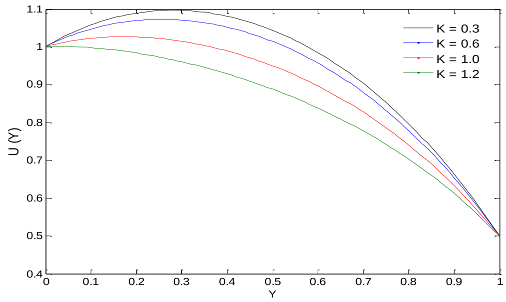

Fig. 11 Variation of K on velocity profile

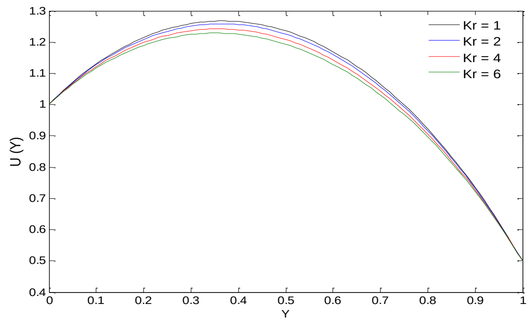

Fig. 12 Variation of Kr on velocity profile

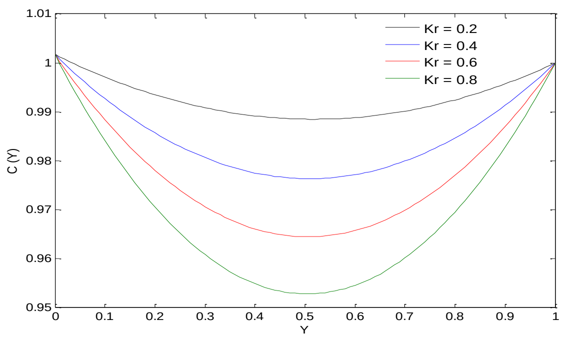

Fig. 13 Variation of Kr on concentration profile

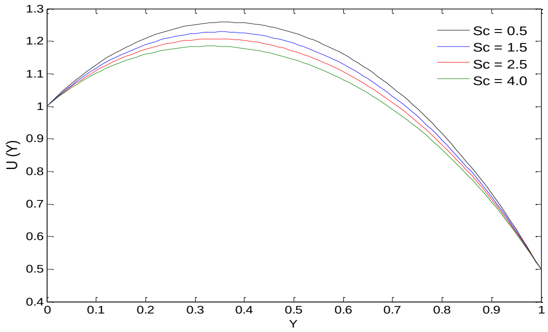

Fig. 14 Variation of Sc on velocity profile

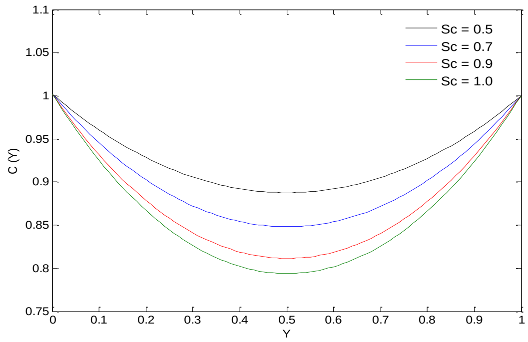

Fig. 15 Variation of Sc on concentration profile

5. CONCLUSION

This work considered heat and mass transfer on unsteady MHD oscillatory flow of a viscous dissipative fluid in a channel filled with porous medium. The obtained non-similar differential equations are solved by perturbation method. The most important concluding remarks can be summarized as follows:

- Velocity decreases with increasing Eckert number, radiation parameter, heat source parameter, magnetic parameter, permeability parameter, chemical reaction parameter and Schmidt number but the Solutal and thermal Grashof number increases the fluid velocity.
- The temperature and concentration at the lower wall is oscillating.
- Temperature decreases as the radiation parameter and heat source parameter increase but it shows opposite effect for the Eckert number.
- Concentration decreases with increase in chemical reaction parameter and Schmidt number.

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