International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Oscillatory Plate Temperature and Unsteady Free Convection Flow of an Suction/ Injection Parameter on MHD in a Vertical Channel.

L. Padmavathi

Assistant Professor, Department of Mathematics, Sai Rajeswari Institute of Technology, Proddatur-516360, A.P, India
E-mail: lekkalapadmamaths@gmail.com

ABSTRACT:

The impact of radiation and suction/ injection in an MHD oscillatory stream past a vertical within constant wall temperature. The fluid is subjected to a transverse attractive field and the velocity slip at the lower plate is taken into consideration. The non-dimensional governing conditions are solved in the closed shape by utilizing the Perturbation method. Correct arrangements are achieved for velocity, and temperature. The effects of main parameters are discussed in various flow fields and presented through graphs.

Key words: oscillatory, MHD, slip, radiation parmeter, prandtal number.

1. INTRODUCTION

The slip impact on the MHD oscillatory stream of fluid in a porous channel with heat and mass exchange and the chemical response has applications within the areas of designing, geophysics, farming, etc. These applications are geothermal stores, heat separators, oil recuperation, and cooling of an atomic reactor. Numerous chemical designing forms like polymer expulsion forms include cooling framework. In this cooling framework, superior electromagnetic properties are regularly utilized as cooling fluid as their stream can be directed by outside attractive areas in arranging to improve the quality of the ultimate item. The oscillatory flow could be a periodic flow that oscillates around a zero value. Oscillatory flow is continuous and always around zero value. Rajesh [1] examined the effects of mass transfer on flow past an impulsively started infinite vertical plate with Newtonian heating and chemical reaction. Raju et al. [2] studied Unsteady MHD free convective oscillatory Couette flow through a porous medium with periodic wall temperature. Reddy et al. [3] examined thermal radiation and chemical response impacts on MHD blended convection boundary layer slipstream in a porous medium with heat source and ohmic heating. Samuel et al. [4] considered MHD oscillatory slipstream and heat exchange in a channel filled with porous media. Singh et al. [5] examined the current impact on visco-elastic MHD oscillatory convective stream through a porous medium in a vertical channel with thermal radiation. Kulkarni [6] examined an MHD stream of an elastic-viscous incompressible fluid through a porous medium between two parallel plates beneath the impact of an attractive field. Ibrahim et al. [7] Chemically reacting MHD boundary layer flow of heat and mass transfer over a moving vertical plate with suction.

The boundary layer flow, heat, and mass transfer over a stretching surface have benefitted believed attention due to its demand in the industrial and manufacturing processes. Such demanded applications are of polymer, chemical industries, controlling of cooling and heating processes and blood flows. Sakiadis [8] considered boundary layer behavior on a continuous solid surface: Boundary layer equations for two-dimensional and axisymmetric flow. Ali et al. [9] studied laminar mixed convection from a continuously moving vertical surface with suction or injection. Magyari et al. [10] considered heat and mass transfer characteristics of the self-similar boundary-layer flows induced by continuous surfaces stretched with rapidly decreasing velocity. Chakma [11] explained An analytical solution for MHD flow past a permeable vertical stretching surface with the existing chemical reaction. Raptis et al.[12] analyzed Viscous flow over a non-linearly stretching sheet in the presence of a chemical reaction and magnetic field. Umamaheswar et al. [13] Studied unsteady MHD free convective visco-elastic fluid flow bounded by an unbounded slanted permeable plate within the nearness of a heat source, gooey scattering, and ohmic heatings. Das et al. [14] Considered Magnetohydrodynamic blended convective slip flow over a slanted porous plate with viscous dissipation and Joule heating.

There are a few examinations on the impacts heat and mass exchange on fluid flow in several physical circumstances. Since of its significance in mechanical applications such as control transformer-electronics,semi-conductor-electronics, retention reactors, parallel dissemination systems, solar vitality frameworks, and polymer handling within the plastics businesses. In specific, a blended convec tion boundary layer stream over an extending sheet is broadly utilized in chemical and auto-mobile businesses. Dipankar Chatterjee et al. [15] investigated MHD stream and heat transfer behind a square barrel in a channel underneath a strong essential appealing field. Turkyilmazoglu [16] considered heat and mass trade of MHD minute organizes slip stream. Mishra et al. [17] studied Mass and heat transfer effect on MHD flow of a visco-elastic fluid through a porous medium with oscillatory suction and heat source. Abdul Gaffar et al. [18] considered numerical ponder of stream and heat exchange of non-Newtonian digression hyperbolic fluid from a circle with biot number impacts.

In view of these facts, the present paper focused on exploring systematically the impact of radiation and suction/ injection in an MHD oscillatory stream past a vertical within constant wall temperature . The fluid is subjected to a transverse attractive field and the velocity slip at the lower plate is taken into consideration. The non-dimensional governing conditions are solved in the closed shape by utilizing the Perturbation method. Correct arrangements are achieved for velocity, and temperature. The effects of main parameters are discussed in various flow fields and presented through graphs.

2. MATHEMATICAL FORMULATION

Consider the unsteady laminar flow of an incompressible viscous electrically conducting fluid through a channel with slip at the cold plate. An outside attractive field is set over the ordinary to the channel. It is accepted that the fluid Porous media incorporates a small electrical conducting and the electromagnetic drive delivered is additionally exceptionally little. The stream is subject to suction at the cold wall and injection at the heated wall. Select a Cartesian facilitate a framework (,). Where lies a along the center of the channel, and are the separate measured within the ordinary area such that = a is the channel's half-width as appeared in Fig.1.1.

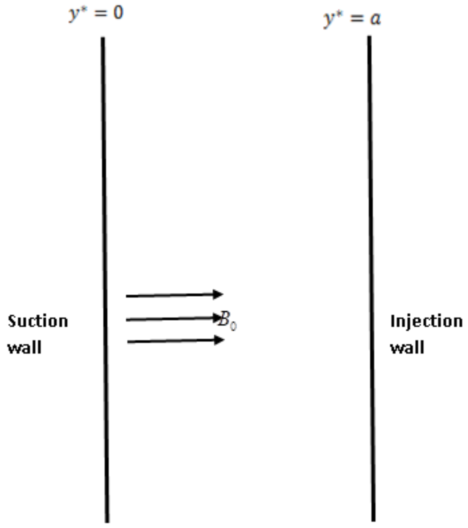

Fig.1.1 Physical model of the problem

According to these assumptions, the set of governing equations for the present paper can be constructed as follows:

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1.1}$$

$$\frac{\partial u^*}{\partial t^*} - v_0 \frac{\partial u^*}{\partial y^*} = -\frac{1}{\rho}\frac{dp^*}{dx^*} + \upsilon \frac{\partial^2 u^*}{\partial y^{*2}} - \frac{\sigma B_0^2}{\rho} u^* - \frac{\upsilon}{k_p} u^* + g\beta(T - T_0) \tag{1.2}$$

$$\frac{\partial T^*}{\partial t^*} - v_0 \frac{\partial T^*}{\partial y^*} = \frac{\kappa}{\rho C_P}\frac{\partial^2 T^*}{\partial y^{*2}} - \frac{1}{\rho C_P}\frac{\partial q_r}{\partial y^*} \tag{1.3}$$

The radiative heat flux q_r can be expressed as the form

$$q_r = \frac{-4\sigma^*}{3k^*}\frac{\partial T^4}{\partial z} \tag{1.4}$$

Where k^* is the mean absorption coefficient, σ^* is the Stefan-Boltzmann constant and the the temperature differences within the flow are sufficiently small so that T^{*4} can be expressed as a linear function of T after using Taylor's series to expand T^{*4} about the free stream temperature T_0 and neglecting higher- order terms.

$$T^4 = 4T_0^3 T - 3T_0^4 \tag{1.5}$$

Thus substituting Eq. (1.5) in Eq. (1.4), we get

$$q_r = -\frac{16\sigma T_0^3}{3k^*}\frac{\partial T}{\partial y} \tag{1.6}$$

Then the heat transfer equation becomes

$$\frac{\partial T^*}{\partial t^*} - \nu_0 \frac{\partial T^*}{\partial y^*} = \frac{\kappa}{\rho C_P}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{16\sigma^* T_0^3}{3\rho C_P k^*}\frac{\partial^2 T}{\partial y^2} \tag{1.7}$$

The corresponding initial and boundary conditions are

$$u^* = \frac{\sqrt{K}}{\alpha_S}\frac{du^*}{dy^*},\ \mathrm{T} = T_0, \qquad on \quad y^* = 0. \tag{1.8}$$

Introduced the following dimensionless variables

$$(X,Y) = \frac{(x^*, y^*)}{h}, u = \frac{hu^*}{\upsilon}, t = \frac{\upsilon t^*}{h^2}, p = \frac{h^2 p^*}{\rho \upsilon^2}, \theta = \frac{(T - T_0)}{(T_1 - T_0)}$$

$$Gr = \frac{g\beta(T_1 - T_0)h^3}{\upsilon^2}, \Pr = \frac{\mu C_P}{\kappa}, \gamma = \frac{\sqrt{K}}{\alpha_S h}, M^2 = \frac{\sigma B_0^2 h^2}{\rho \upsilon}, K = \frac{k_p}{h^2},\ s = \frac{\nu_0 h}{\upsilon}, R = \frac{16\bar{\sigma} h^2 T_0^3}{3\kappa k^*}$$

By using dimensionless variables, the governing equations can be reduces to

$$\frac{\partial u}{\partial t} - s\frac{\partial u}{\partial y} = -\frac{dp}{dx} + \frac{\partial^2 u}{\partial y^2} - \left(M^2 + \frac{1}{K}\right)u + Gr\theta \tag{1.9}$$

$$\frac{\partial \theta}{\partial t} - s\frac{\partial \theta}{\partial y} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} + \frac{R}{\Pr}\theta \tag{1.10}$$

The corresponding initial and boundary conditions reduces to

$$u = \gamma\frac{du}{dy},\quad \theta = 0, \quad on \quad y = 0$$

$$u = 0, \quad \theta = 0, \quad on \quad y = 1 \tag{1.11}$$

In Eqs. (1.9) - (1.10), K is the porosity parameter, s is the Suction/injection parameter, M is the magnetic parameter, Gr is the Grashof number, $\Pr$ is the prandtl number, R is the Radiation parameter, and γ is the Navier slip parameter.

3. SOLUTION OF THE PROBLEM

In order to solve the non-linear system of equations (1.9) to (1.10) with the boundary conditions (1.11).

$$-\frac{dp}{dx} = \lambda e^{i\omega t}, u(t,y) = u_0(y)e^{i\omega t}, \theta(t,y) = \theta_0(y)e^{i\omega t} \tag{1.12}$$

Where λ is any positive constant and ω is the frequency of oscillation. Substituting equations (1.12) into the equations (1.9) and (1.10) and the boundary conditions (1.11) are reduces the following non-dimensional forms

$$u_0'' + su_0' - \left(M^2 + \frac{1}{K} + i\omega\right)u_0 = -\lambda - Gr\theta_0 \tag{1.13}$$

$$\theta_0'' + s\Pr\theta_0' + ((-i\omega)\Pr + R)\theta_0 = 0 \tag{1.14}$$

The non-dimensional boundary conditions are,

$$u_0(0) = \gamma u_0^{'}(0), \theta_0(0) = 0, u(1) = 0, \theta_0(1) = 1 \qquad (1.15)$$

In view of the above solutions, the velocity and temperature equation becomes

$$u(y,t) = (A_1 e^{m_3 y} + B_1 e^{m_4 y} + Q_0 + Q_1 e^{m_1 y} + Q_2 e^{m_2 y}) e^{i\omega t} \qquad (1.16)$$

$$\theta(y,t) = (A_0 e^{m_1 y} + B_0 e^{m_2 y}) e^{i\omega t} \qquad (1.17)$$

The parameters τ, Nu_x can be defined and determined as

The rate of Shear stress is

$$\tau = \frac{\partial u}{\partial y} = (A_1 m_3 e^{m_3 y} + B_1 m_3 e^{m_4 y} + Q_0 + Q_1 m_1 e^{m_1 y} + Q_2 m_2 e^{m_2 y}) e^{i\omega t} \qquad (1.18)$$

The rate of Heat transfer/Nusselt Number is

$$Nu_x = \frac{\partial \theta}{\partial y} = (A_0 m_1 e^{m_1 y} + B_0 m_2 e^{m_2 y}) e^{i\omega t} \qquad (1.19)$$

4. RESULTS AND DISCUSSIONS

The set of non-linear ordinary differential equations (1.13)-(1.14) with the boundary conditions (1.15) are difficult to solve analytically, hence they are solved numerically by using the Perturbation technique in MATLAB. Figs 1.2 - 1.11 are tactical representations of different flow parameters on velocity and temperature fields. As long as there is no special indication, the entire investigation is based on the fixed values of physical parameters $Pr = 0.63$, $Gr = 3$, $\omega = \pi/2, \lambda = 1, M = K = s = R = 1$.

In Fig. 1.2, the effect of the retarding effect of Lorentz forces present in the magnetic field on the fluid flow is presented. It is observed that maximum flow occurs in the absence of the magnetic field, and further increase in the magnetic field parameter (M) is seen to decrease the fluid velocity. In Fig. 1.3, presents the plot of increment in channel porosity parameter (K) on the velocity profile. As observed, the porosity parameter (K) of the medium increases, there's an increase within the fluid velocity . In Fig.1.4, shows the buoyancy effect on the fluid flow during heating (Gr) as observed, and an increase in the Grashof number enhances the fluid flow velocity. As observed in Fig. 1.5, as the Navier slip parameter (γ) increments at the cold wall, there's a comparable rise within the velocity at the cold wall. In Fig.1.6, the result appears that as the injection parameter (s) increases, there's an increase within the fluid velocity. Whereas as the suction parameter (s) decreases, there's a decrease within the fluid velocity due to cooling. In Fig.1.7, displays the effect of pressure gradient (λ) on velocity. In Fig.1.8, it is observed that an increase in the radiation parameter (R) decreases the fluid velocity due to internal heat generation that enhances the fluid flow.

From Fig.1.9, it is observed that an increase in the frequency of prandtl number$(Pr \quad)$ increases the fluid temperature within the channel. From Fig.1.10, it is observed that an increase in radiation parameter (R) decreases the fluid temperature inside the channel. In Fig.1.11, the result appears that as the injection parameter (s) increases, there's an increase within the fluid temperature. Whereas as the suction parameter (s) decreases, there's a reduction within the fluid temperature.

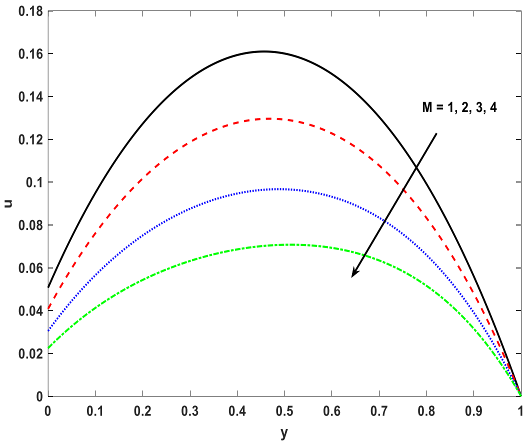

Fig.1.2. Effect of M on velocity.

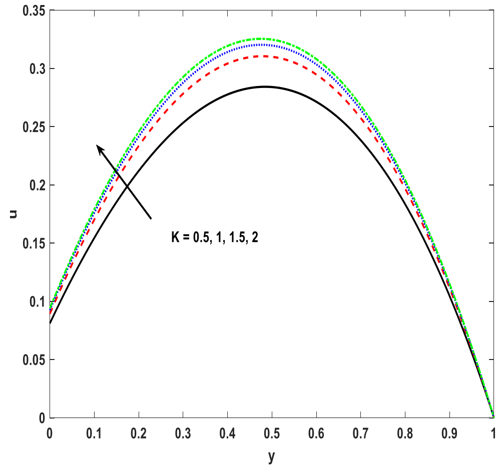

Fig.1.3. Effect of K on velocity.

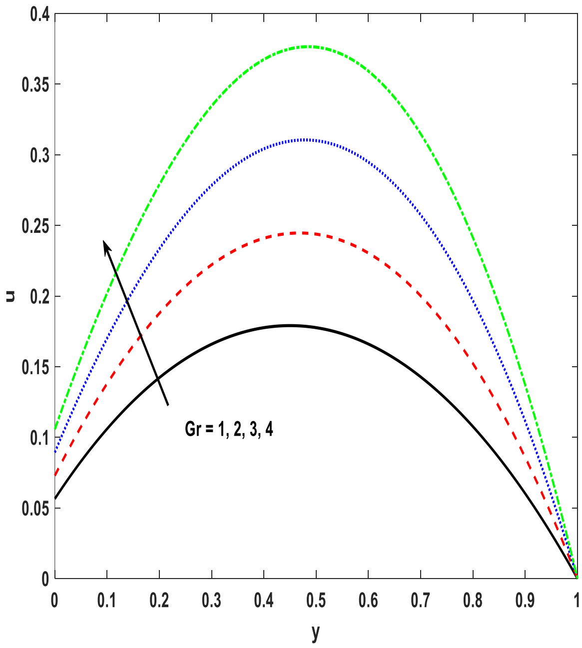

Fig.1.4. Effect of Gr on velocity

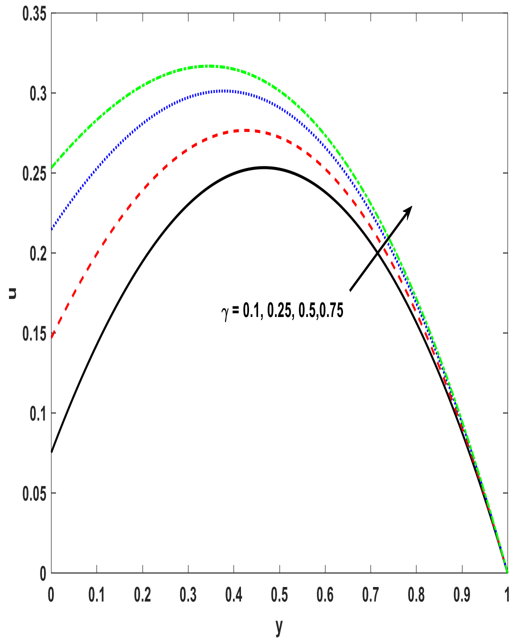

Fig.1.5. Effect of γ on velocity

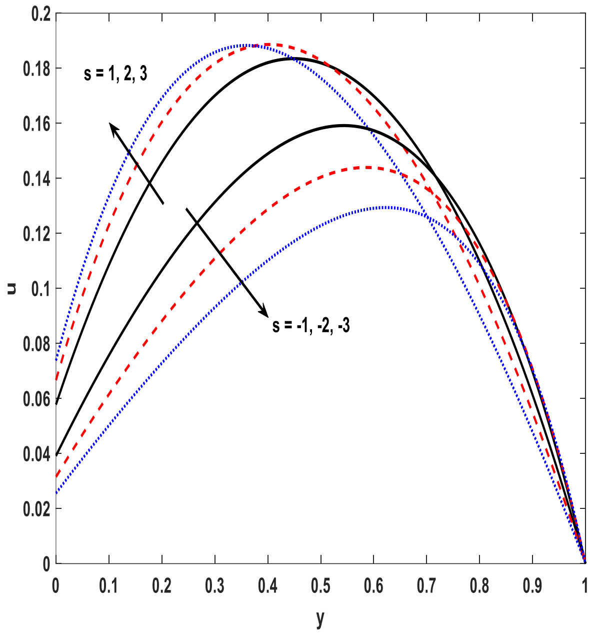

Fig.1.6. Effect of S on velocity

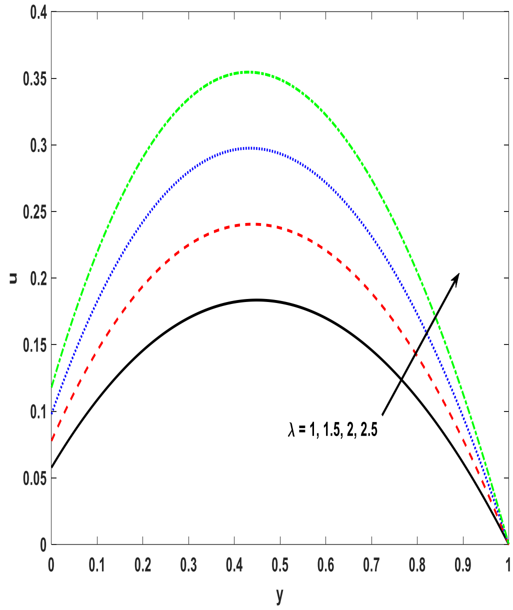

Fig.1.7. Effect of λ on velocity

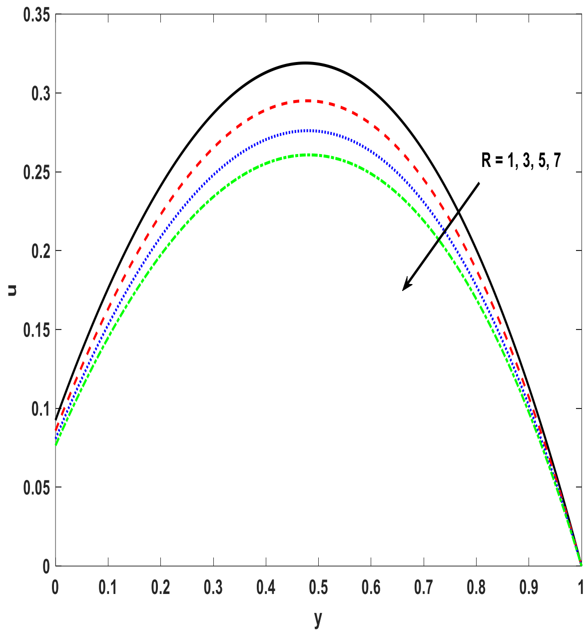

Fig.1.8. Effect of R on velocity

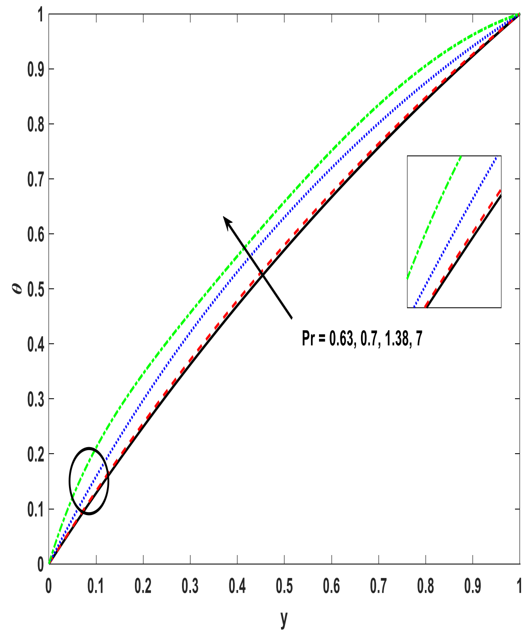

Fig.1.9. Effect of $\Pr$ on temperature

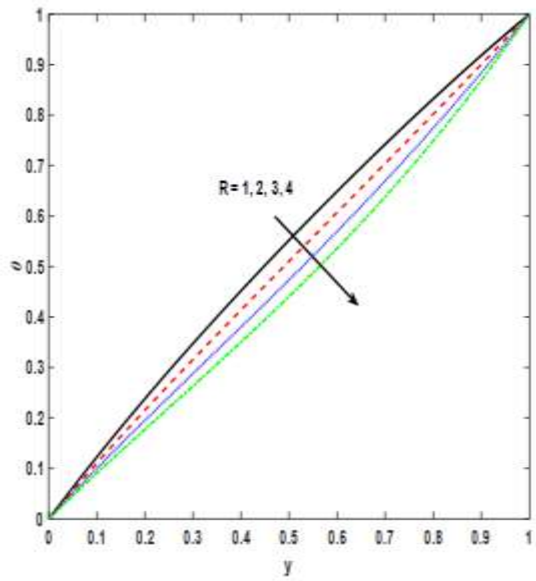

Fig.1.10. Effect of on temperature

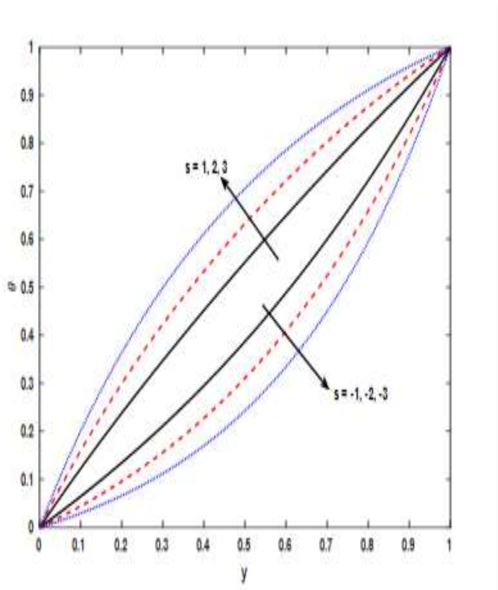

Fig.1.11. Effect of on temperature

CONCLUSIONS

An analysis is done systematically on Study of flow characteristics of conducting fluid embedded in porous media. The governing equations for the velocity field, temperature by perturbation technique in terms of dimensionless parameters. The findings of this study are as follows:

1. As the porosity parameter , Navier slip parameter , Grashoff number , pressure gradient are increased, then velocity profile increases between the boundaries.

2. As magnetic parameter , chemical reaction and radiation parameter are increased, then velocity profile diminishes between the boundaries.

3. As the injection parameter increased, the velocity, temperature are increased between the boundaries. Whereas as the suction parameter reduces, the velocity, temperature decreases between the boundaries.

4. As the radiation parameter increases, the temperature profile decreases between the boundaries.

APPENDIX

$$m_1 = \frac{-s\,\mathrm{Pr} + \sqrt{(s\,\mathrm{Pr})^2 - 4(-i\omega)\,\mathrm{Pr} - R)}}{2} \qquad m_2 = \frac{-s\,\mathrm{Pr} - \sqrt{(s\,\mathrm{Pr})^2 - 4(-i\omega)\,\mathrm{Pr} - R)}}{2}$$

$$m_3 = \frac{-s + \sqrt{s^2 + 4(M^2 + K + i\omega)}}{2} \qquad m_4 = \frac{-s - \sqrt{s^2 + 4(M^2 + K + i\omega)}}{2} \qquad A_0 = -\frac{1}{e^{m_2} - e^{m_1}}$$

$$B_0 = \frac{1}{e^{m_2} - e^{m_1}} \qquad A_1 = \frac{B_1(\gamma m_4 - 1) - n_0 + n_1}{(1 - \gamma m_3)} \qquad B_1 = -\frac{\left(n_2 + \frac{(n_1 - n_0)e^{m_3}}{(1 - \gamma m_3)}\right)}{\left(e^{m_4} + \frac{(\gamma m_6 - 1)e^{m_3}}{(1 - \gamma m_3)}\right)}$$

$$Q_0 = \frac{\lambda}{(M^2 + K + i\omega)} \qquad Q_1 = -\frac{GrA_0}{m_1^2 + sm_1 - (M^2 + K + i\omega)} \qquad Q_2 = -\frac{GrB_0}{m_2^2 + sm_2 - (M^2 + K + i\omega)}$$

$$n_0 = Q_0 + Q_1 + Q_2 \qquad n_1 = m_1\gamma Q_1 + m_2\gamma Q_2 \qquad n_2 = Q_0 + Q_1 e^{m_1} + Q_2 e^{m_2}$$

REFERENCES

[1] V. Rajesh, Effects of mass transfer on flow past an impulsively started infinite vertical plate with Newtonian heating and chemical reaction, J. Engng. Phys. Thermophys, 85 (2012) 205–211.

[2] M.C. Raju, S.V.K.Varma, Unsteady MHD free convective oscillatory couette flow through a porous medium with periodic wall temperature, J. Fut. Eng. Tech, 6(4) (2011) 7–12.

[3] M.G. Reddy, Thermal radiation and chemical reaction effects on MHD mixed convection boundary layer slip flow in a porous medium with heat source and ohmic heating, Eur. Phys. J. Plus, 129 (2014) 41-51.

[4] O.A. Samuel, O.D. Makinde, MHD oscillatory slip flow and heat transfer in a channel filled with porous media. U.P.B. Sci. Bull., Series A, 76 (2014) 197-204.

[5] K.D. Singh, B.P. Garg and A.K. Bansal, Current effect on visco-elastic MHD oscillatory convective flow through a porous medium in a vertical channel with heat radiation, Proc Indian Natn Sci Acad, 80 (2014) 333-343.

[6] S.B. Kulkarni, Unsteady MHD flow of elastico-viscous incompressible fluid through a porous medium between two parallel plates under the influence of a magnetic field, Defence Science Journal, 65 (2015)119-125.

[7] S.Y. Ibrahim and O.D. Makinde, Chemically reacting MHD boundary layer flow of heat and mass transfer over a moving vertical plate with suction, Scientific Research and Essays, 5 (2010) 2875-2882.

[8] B.C. Sakiadis, Boundary layer equations for two-dimensional and axisymmetric flow, J. Amer. Inst. Chem. Eng. ,7 (1961) 26-28.

[9] M.E. Ali, F. Al-Yousef, Laminar mixed convection from a continuously moving vertical surface with suction or injection, Heat and Mass Transfer, 33 (1998) 301-306.

[10] E. Magyari, M. E. Ali, B.Keller, Heat and mass transfer characteristics of the self-similar boundary-layer flows induced by continuous surfaces stretched with rapidly decreasing velocities, Heat and Mass Transfer , 38 (2001) 65-74.

[11] A. J. Chamka, MHD flow of a uniformly stretched vertical permeable surface in the presence of heat generation/absorption and a chemical reaction, Int. Comm. Heat Mass Trans., 30 (2003) 413-422.

[12] A. Raptis, C.Perdikis, Viscous flow over a non-linearly stretching sheet in the presence of a chemical reaction and magnetic field, Int. J. Non-linear Mech., 41 (2006) 527-529.

[13] M. Umamaheswar, S. V. K. Varma and M. C. Raju, Unsteady MHD free convective visco-elastic fluid flow bounded by an infinite inclined porous plate in the presence of heat source viscous dissipation and ohmic heating, International Journal of Advanced Science and Technology, 61 (2013) 39-52.

[14] S. Das, R.N. Jana and O.D. Makinde, Magnetohydrodynamic mixed convective slip flow over an inclined porous plate with viscous dissipation and Joule heating, Alexandria Engineering Journal, 54 (2015) 251–261.

[15] C. Dipankar and G. Satish Kumar, MHD flow and heat transfer behind a square cylinder in a duct under strong axial magnetic field, International Journal of Heat and Mass Transfer, 88 (2015) 1–13.

[16]M. Turkyilmazoglu, Heat and mass transfer of MHD second order slip flow computers &fluids, 71(2013) 426–434 .

[17]S.R. Mishra, G.C. Dash, M. Acharya, Mass and heat transfer effect on MHD flow of a visco-elastic fluid through porous medium with oscillatory suction and heat source, Int. J. of Heat and Mass Transfer, 57 (2013) 433-438.

[18]S. Abdul Gaffar, V. Ramachandra Prasad and O. Anwar Be´g, Numerical study of flow and heat transfer of non-newtonian tangent hyperbolic fluid from a sphere with biot number effects, Alexandria Engineering Journal, 54 (2015) 829–841