International Journal of Engineering, Mathematical and Physical Sciences
ISSN: 2517-9934
Vol:14, No:6, 2020

# Radiation Effects on the Unsteady MHD Free Convection Flow Past in an Infinite Vertical Plate with Heat Source

Tusharkanta Das, Tumbanath Samantara, Sukanta Kumar Sahoo

***Abstract*****—**Unsteady effects of MHD free convection flow past in an infinite vertical plate with heat source in presence of radiation with reference to all critical parameters that appear in field equations are studied in this paper. The governing equations are developed by usual Boussinesq's approximation. The problem is solved by using perturbation technique. The results are obtained for velocity, temperature, Nusselt number and skin-friction. The effects of magnetic parameter, prandtl number, Grashof number, permeability parameter, heat source/sink parameter and radiation parameter are discussed on flow characteristics and shown by means of graphs and tables.

***Keyword*****—**Heat transfer, radiation, MHD, free convection, porous medium, suction.

## NOMENCLATURE

| | |
|---|---|
| $C_P$ | Specific heat at constant pressure |
| g | Acceleration due to gravity |
| Gr | Thermal Grashoff number |
| k ' | Thermal conductivity of the fluid |
| $P_r$ | Prandtl number |
| $q_r$ | Radiative heat flux in the y-direction. |
| k | Thermal diffusivity |
| K | Porosity |
| M | Magnetic field |
| R | Radiation parameter |
| t | Time |
| S | Suction parameter |
| T' | Temperature of the fluid near the plate |
| $T_1'$ | Temperature of the plate. |
| $T_0'$ | Temperature of the fluid far away from the plate |
| u' | Velocity of the fluid in the x-direction |
| $V_0$ | Velocity of the fluid plate |
| u | Dimensionless velocity |
| y | Co-ordinate axis normal to the plate |
| y ' | Dimensionless co-ordinate axis normal to the plate |
| ω | Frequency of oscillations |
| θ | Dimensionless temperature |
| α | Thermal conductivity |
| β | Volumetric coefficient of thermal equation |
| ρ | Density |
| υ | Kinematic viscosity |
| τ | Dimensionless skin friction |
| $\beta_v$ | Volumetric coefficient of expansion with concentration |

T. K. Das and S. K. Sahoo are with the Gandhi Institute of Technology & Management, BBSR, Odissa, India (e-mail: tusharkant.dash078@gmail.com, sukasahoo@gmail.com).

T. Samantara is with the Centurian University of Technology & Management, BBSR, Odisha, India (e-mail: tnsamantara@gmail.com).

## I. INTRODUCTION

THE magneto hydrodynamics flow and heat transfer over an infinite vertical porous plate with slip flow region has many applications such as metal spinning, glass fiber production, wire drawing, paper production and many others. In recent years MHD flow problems have come in view of its significant applications in industrial manufacturing process such as plasma studies, petroleum industries, power generators cooling of clear reactors and boundary layer control in aerodynamics. MHD free convection fluid flows frequently occur in natural world. Fluid passing through porous medium is of great interest now a days and many researchers are attracted towards the applications in the fields of science and technology, namely in the area of agriculture engineering to know about ground water resources, in technology to study the moment of natural gas oil and water through the oil reservoirs. The conventional approach in porous media transport modeling has been to simulate the pressure drop across the porous regime using the Darcy linear model. This basically adds an extra body force to the momentum boundary layer equation. Heat transfer by thermal radiation is to be more important and it concerned with space application, power engineering, nuclear power plants, gas turbines, missiles, satellites etc. In astrophysics and geophysics, it is mainly applied to study the stellar and solar structures, interstellar matter, radio propagation through the ionosphere etc.

Mansour [1] investigated the thermal radiation and free convection effects in the oscillatory flow past a vertical plate. Vajravelu and Hadjinicolaou [2] studied heat transfer characteristics in the laminar boundary layer of a viscous fluid over a linearity stretching, continuous surface with variable wall temperature on effects of frictional heating and internal heat generation. Soundalgekar [3] worked in hydro-magnetic natural convection flow past a vertical surface. Helmy [4] investigated MHD unsteady free convective flow past a vertical porous plate. Hossain et al. [5] investigated heat transfer response of MHD free convective flow along a vertical plate to surface temperature oscillation. Kim [6] founded an unsteady MHD convective heat transfer past a semi-infinite vertical porous moving plate with variable suction. El-Naby et al. [7] have numerically investigated radiation effects on magnetohydrodynamic (MHD) unsteady free-convection flow past a semi-infinite vertical plate with variable surface temperature in the presence of transversal uniform magnetic field. Zhang et al. [8] have studied the free convection effects on a heated vertical plate subjected to a periodic oscillation. The radiation effects on an unsteady free convective flow through a porous medium bounded by an oscillating plate with a variable wall temperature have been studied by [9]. Chandrakala et al. [10] have studied the radiation effects on the flow of a semi-infinite vertical plate with uniform heat flux in the presence of transversel magnetic field. Chandrakala et al. [11] have studied the thermal radiation effects of an MHD flow past an infinite vertical oscillating plate in the presence of transverse magnetic field. Kumar [12] have considered the boundary layer steady flow and heat transfer of a viscous incompressible fluid due to a stretching plate with viscous dissipation effect in presence of transfer magnetic field. The unsteady free convection flow on a vertical oscillating porous plate with constant heating has been studied by [13]. The problem of dissipation effects on MHD nonlinear flow and heat transfer past a porous surface with prescribed heat flux has been studied by [14]. The free convective flow past an impulsively started infinite vertical plate with uniform heat flux in the presence of thermal radiation and magnetic effects by considering the porosity of the fluid bed has been investigated by [15]. Effects of radiation on unsteady MHD free embedded in a porous medium with oscillatory heat flux have been studied by [16]. Senapati et al. [17] have analyzed radiation effects of MHD free convective heat transfer past an oscillating hot vertical surface in porous medium. Ahmad et al. [18] have studied MHD flow over stretching porous sheet and for magneto hydrodynamic stagnation point flow over a stretching sheet. Ahmad et al. [19] have considered MHD flow and heat transfer through a porous medium over a stretching/shrinking surface with suction. Sai et al. [20] have studied unsteady MHD free convective flow past an infinite vertical porous plate with uniform heat flux in the presence of thermal radiation.

In the present analysis, it is proposed to study the unsteady effects of MHD free convection flow past in an infinite vertical plate with heat source in presence of radiation. The dimensionless governing equations are solved using perturbation technique. Results are presented graphically and discussed quantitatively for parameter values of practical interest from physical point of view.

## II. Problem Formulation

Let us consider the unsteady laminar two-dimensional free convection boundary layer flow of a viscous incompressible electrically conducting fluid past in an infinite vertical plate with heat source in presence of radiation * kept at constant temperature $T_1'$ and the fluid has internal volumetric rate of heat generation $\theta_0$. The x-axis is taken along the plate in the vertical direction and y-axis is normal to the plate. Magnetic field of intensity $B_0$ is applied in y-direction. It is assumed that the external field is zero, also electrical field due to polarization of charges and Hall effects are neglected. Incorporating the Boussinesq's approximation within the boundary layer, the governing equations of continuity, momentum and energy [21]-[25] respectively are given by

$$\frac{\partial v'}{\partial y'} = 0 \Rightarrow v' = -v_0\ (constant) \tag{1}$$

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = \nu\frac{\partial^2 u'}{\partial y'^2} + g\beta\left(T' - T_\theta'\right) - \frac{\sigma B_0^2 u'}{\rho} - \frac{\nu}{k'}u' \tag{2}$$

$$\rho C_p\left(\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'}\right) = k\frac{\partial^2 T'}{\partial y'^2} - \frac{\partial q_r}{\partial y'} - \theta_0\left(T' - T_\infty'\right) \tag{3}$$

The appropriate boundary conditions are given by

$$\left.\begin{array}{c} y' = 0 : u' = V_0\left(1 + \varepsilon e^{i\omega' t'}\right), T' = T_1' + \varepsilon(T_1' - T_0')e^{i\omega' t'} \\ y' = \infty : u' = 0, T' = T_0' \end{array}\right\} \tag{4}$$

In the optically thick limit, the fluid does not absorb its own emitted radiation in which there is no self-absorption, but it does absorb radiation emitted by the boundaries. Cogley et al. [8] showed that in the optically thick limit for a non-gray gas near equilibrium given as

$$\frac{\partial q_r}{\partial y'} = 4\alpha^2\left(T' - T_0'\right) \tag{5}$$

On introducing the following non-dimensional quantities

$$\left.\begin{array}{c} u = \frac{u'}{V_0}, v = \frac{v'}{V_0}, y = \frac{y' V_0}{\nu}, t = \frac{t' V_0^2}{\nu} \\ \omega = \frac{\omega' \nu}{V_0^2}, \theta = \frac{T' - T_0'}{T_1' - T_0'}, Pr = \frac{\rho \nu C_p}{k} \\ M = \frac{\sigma \nu B_0^2}{\rho V_0^2}, S = \frac{\nu \theta_0}{\rho c_p V_0^2}, K = \frac{k' V_0^2}{\nu^2} \\ R = \frac{4\alpha^2 \nu^2}{k V_0^2}, Gr = \frac{g\beta\nu\left(T_1' - T_0'\right)}{V_0^3} \end{array}\right| \tag{6}$$

where Gr is Grashof number, M is magnetic field strength, Pr is Prandtl number, R is radiation parameter, K is permeability parameter of the porous medium and $S$ is Source/sink parameter.

Using (5)-(6) in (1)-(3) and in boundary conditions (4) we get

$$\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + Gr\theta - \left(\frac{1}{K} + M\right)u \tag{7}$$

$$\frac{\partial \theta}{\partial t} - \frac{\partial \theta}{\partial y} = \frac{1}{P_r}\left(\frac{\partial^2 \theta}{\partial y^2}\right) - \left(\frac{R}{P_r} + S\right)\theta \tag{8}$$

The corresponding boundary conditions are

$$\left.\begin{array}{c} y = 0 :\ u = 1 + \varepsilon e^{i\omega t}, \theta = 1 + \varepsilon e^{i\omega t} \\ y \to \infty :\ u \to 0, \theta \to 0 \end{array}\right\} \tag{9}$$

## III. Method of Solution

In view of boundary condition (9),we assume the solutions of coupled nonlinear equations (7)-(8) as

$$\left.\begin{array}{c} u(y,t) = u_0(y)e^{i\omega t} \\ \theta(y,t) = \theta_0(y)e^{i\omega t} \end{array}\right\} \tag{10}$$

Under the modified initial and boundary conditions:

$$\left.\begin{array}{c} u_0 = (1+\varepsilon e^{i\omega t})e^{-iwt}, \theta_0 = (1+\varepsilon e^{i\omega t})e^{-iwt} at y = 0 \\ u_0 \to 0, \theta_0 \to 0 \ as y \to \infty \end{array}\right\} \quad (11)$$

Using (10) & (11) in (7) & (8), we obtain the mean velocity U and mean temperature θ as follows

$$U = b_1 e^{-a_5 y} - A_1 e^{-a_4 y}(e^{-a_5 y} - 1) \quad (12)$$

$$\theta = b_1 e^{-a_4 y} \quad (13)$$

where $a_1 = M + \frac{1}{K} + i\omega, a_2 = P_r^2 + 4(R + (S + i\omega)P_r), a_3 = 1 - 4a_1, a_4 = \frac{P_r+\sqrt{a_2}}{2}, a_5 = \frac{P_r+\sqrt{a_3}}{2}, A_1 = \frac{G_r b_1}{a_1}, b_1 = 1 + \varepsilon e^{i\omega t}$

The mean skin friction/shearing stress at the plate in dimensional form is given by

$$u'(y)]_{y=0} = -b_1 a_5 + A_1 a_4 \quad (14)$$

The mean rate of heat transfer at the plate/Nusselt number is given by

$$\theta'(y)]_{y=0} = -b_1 a_4 \quad (15)$$

## IV. Discussion and Results

The system of ordinary differential equations (12)-(13) with boundary conditions (11) are solved analytically by employing the perturbation technique. In order to get a physical view of the problem, numerical calculations are carried out for different value of oscillating frequency, Prandtl number, Grashof number, magnetic parameter, source/sink parameter, time, radiation parameter and permeability parameter for velocity profile, temperature profile. The effect of parameters Gr, Pr, M, R, S, K, ω, t, on flow characteristics have been presented in Figs. 1-10 and Tables I and II.

Fig. 1 shows the effect of the parameter $\omega$ on velocity at any point of fluid, when Pr = 0.71, R = 1, S = 1, M = 0.1, K = 1, Gr = 4, t = 2. It is observed that the velocity decreases with the increase of oscillating frequency at any point of fluid.

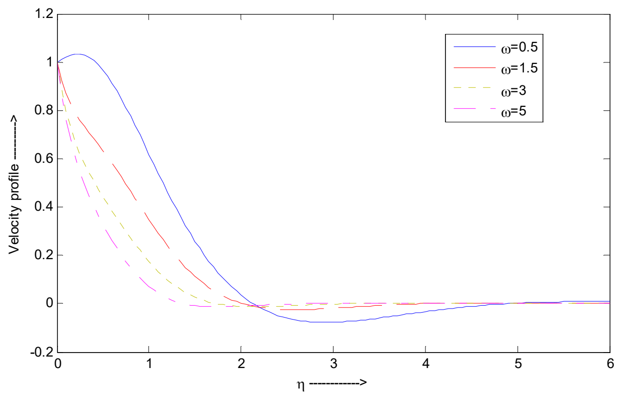


Fig. 1 Effect of $\omega$ on velocity profile, when Pr = 0.71, R = 1, S = 1, M = 0.1, K =1, Gr = 4, $\varepsilon$ = 0.001, t = 2

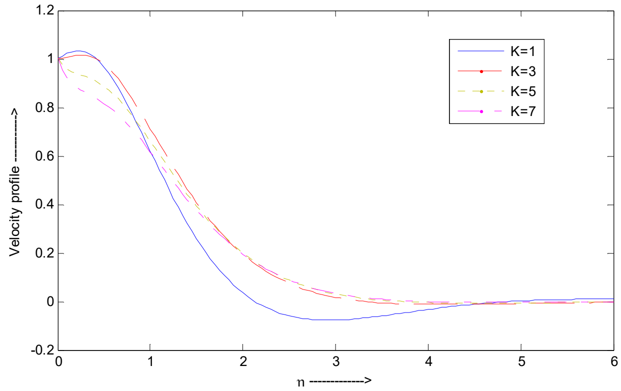


Fig. 2 Effect of K on velocity profile, when $\omega$ = 0.5, Pr = 0.71, R = 1, S = 1, M = 0.1, Gr = 4, $\varepsilon$ = 0.00, t = 2

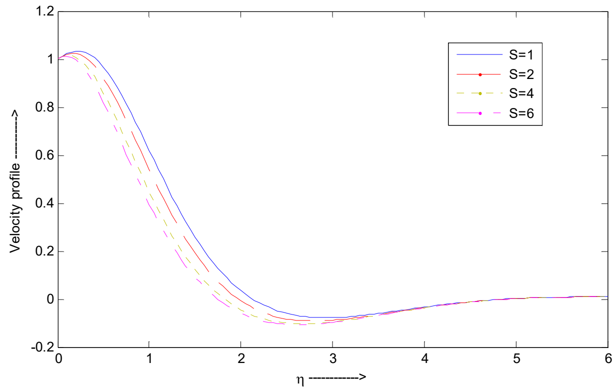


Fig. 3 Effect of S on velocity profile, when $\omega$ = 0.5, Pr = 0.71, R = 1, K = 1, M = 0.1, Gr = 4, $\varepsilon$ = 0.001, t = 2

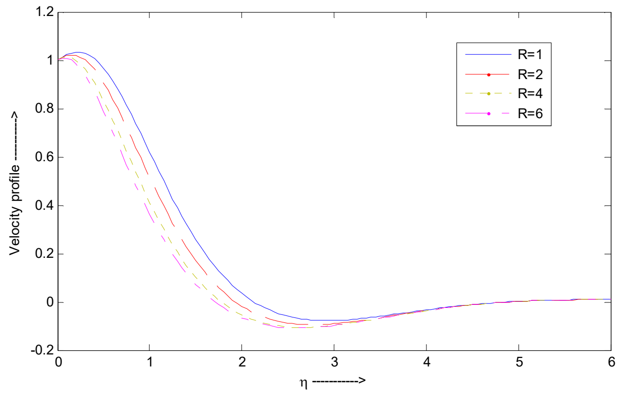


Fig. 4 Effect of R on velocity profile, when $\omega$ = 0.5, Pr = 0.71, S = 1, K = 1, M = 0.1, Gr = 4, $\varepsilon$ = 0.001, t = 2

Fig. 2 shows the effect of the parameter K on velocity at any point of fluid, when Pr = 0.71, R = 1, S = 1, M = 0.1, $\omega$ = 0.5, Gr = 4, t = 2. It is observed that the velocity increases with the increase of porous parameter at any point fluid.

Fig. 3 shows the effect of the parameter S on velocity at any point of fluid, when Pr = 0.71, R = 1, K = 1, M = 0.1, $\omega$ = 0.5, Gr = 4, t = 2. It is observed that the velocity decreases with the increase of suction parameter at any point fluid.

Fig. 4 shows the effect of the parameter R on velocity at any point of fluid, when Pr = 0.71, S = 1, K = 1, M = 0.1, $\omega$ = 0.5, Gr = 4, t = 2. It is observed that the velocity decreases with the increase of radiation parameter at any point fluid.

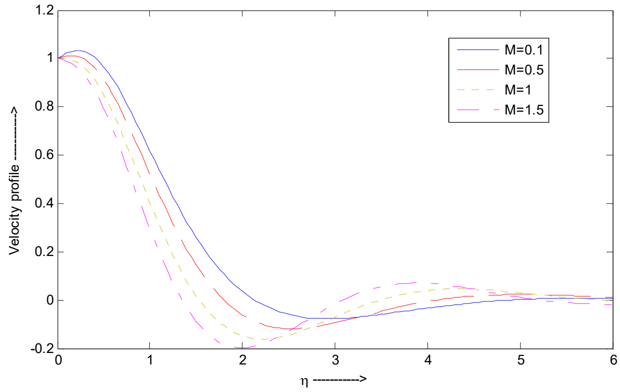


Fig. 5 Effect of M on velocity profile, when $\omega$ = 0.5, Pr = 0.71, S = 1, K = 1, R = 1, Gr = 4, $\varepsilon$ = 0.001, t = 2

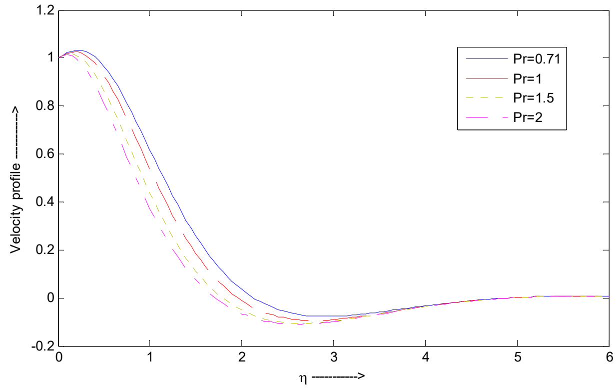


Fig. 6 Effect of Pr on velocity profile, when $\omega$ = 0.5, M = 0.1, S = 1, K = 1, R = 1, Gr = 4, $\varepsilon$ = 0.001, t = 2

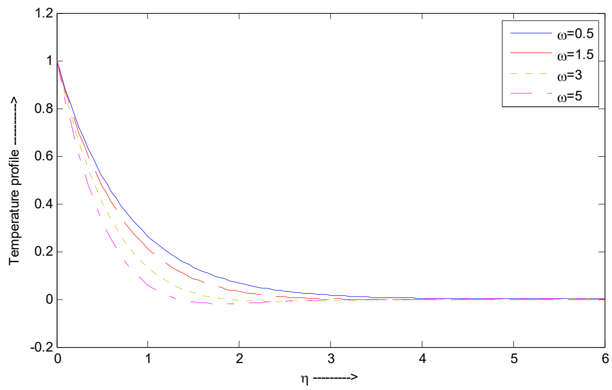


Fig. 7 Effect of on$\omega$ temperature profile when, Pr = 0.71, R = 0.05, S = 1, $\varepsilon$ = 0.001, t = 2

Fig. 5 shows the effect of the parameter M on velocity at any point of fluid, when Pr = 0.71, R = 1, K = 1, S = 1, $\omega$ = 0.5, Gr = 4, t = 2. It is observed that the velocity decreases near to the plate and then increases away from the plate with the increase of magnetic parameter at any point fluid.

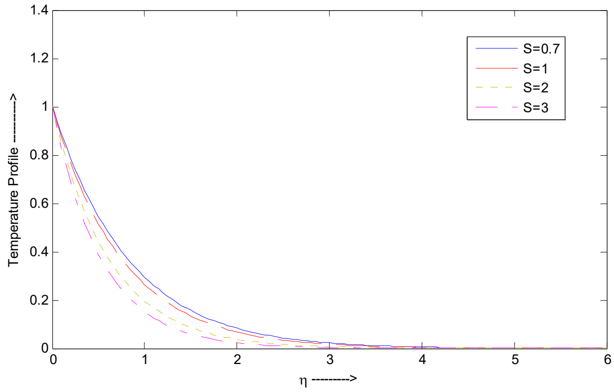


Fig. 8 Effect of S on temperature profile when, Pr = 0.71, R = 0.05, $\omega$ = 0.5, $\varepsilon$ = 0.001, t = 2

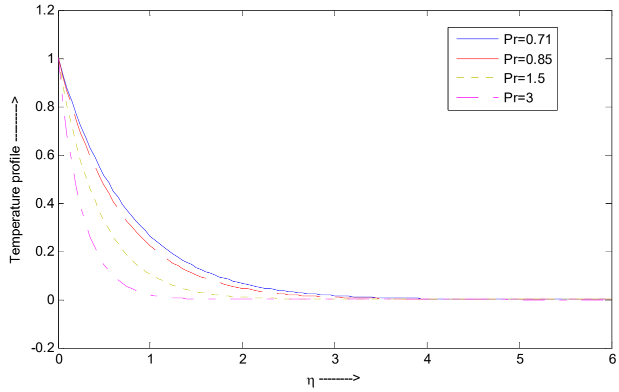


Fig. 9 Effect of Pr on temperature profile when, S = 1, R = 0.05, $\omega$ = 0.5, $\varepsilon$ = 0.001, t = 2

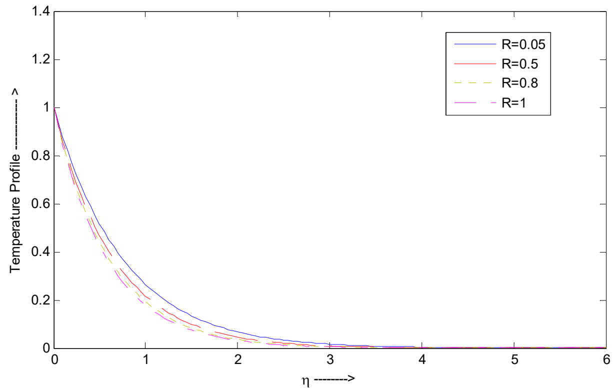


Fig. 10 Effect of R on temperature profile when, S = 1, Pr = 0.71, $\omega$ = 0.5, $\varepsilon$ = 0.001, t = 2

Fig. 6 shows the effect of the parameter Pr on velocity at any point of fluid, when M = 0.1, R = 1, K = 1, S = 1, $\omega$ = 0.5, Gr = 4, t = 2. It is observed that the velocity decreases with the increase of Prandtl number at any point fluid.

Table I shows the effect of skin friction. It is noticed that the skin friction increases with the increase of suction parameter (S), Prandtl number (Pr), radiation parameter (R), magnetic parameter (M), porous parameter (K), thermal Grashof number (Gr) and decreases with the increase oscillating frequency.

Figs. 7-10 show the effects of the temperature profile. It is observed that the temperature falls with increases of the suction parameter (S), Prandtl number (Pr), oscillating parameter ($\omega$) and radiation parameter (R).

Table II shows the effect of Nusselt number. It is noticed that the Nusselt number increases with the increase of radiation parameter (R), oscillating parameter ($\omega$) and decreases with the increase of suction parameter (S), Prandtl number (Pr).

TABLE I
EFFECT OF $\omega$, S, PR, R, M, K, AND GR ON SKIN FRICTION

| Ω | S | Pr | R | M | K | GR | Skin friction |
|---|---|---|---|---|---|---|---|
| 0.5 | 1 | 0.71 | 1 | 0.1 | 1 | 4 | 4.5949 |
| 1.5 | 1 | 0.71 | 1 | 0.1 | 1 | 4 | 1.7346 |
| 0.5 | 1.2 | 0.71 | 1 | 0.1 | 1 | 4 | 4.7417 |
| 0.5 | 1 | 0.85 | 1 | 0.1 | 1 | 4 | 5.0461 |
| 0.5 | 1 | 0.71 | 2 | 0.1 | 1 | 4 | 5.5440 |
| 0.5 | 1 | 0.71 | 1 | 0.5 | 1 | 4 | 3.5077 |
| 0.5 | 1 | 0.71 | 1 | 0.1 | 3 | 4 | 6.4834 |
| 0.5 | 1 | 0.71 | 1 | 0.1 | 1 | 3 | 3.2561 |

TABLE II
EFFECT OF S, PR, R AND $\omega$ ON NUSSELT NUMBER

| Pr | S | Ω | R | Nu |
|---|---|---|---|---|
| 0.71 | 1 | 0.5 | 0.05 | -1.3149 |
| 0.75 | 1 | 0.5 | 0.05 | -1.3638 |
| 0.71 | 1.2 | 0.5 | 0.05 | -1.3841 |
| 0.71 | 1 | 0.7 | 0.05 | -1.3301 |
| 0.71 | 1 | 0.5 | 0.07 | -1.3249 |

## V. CONCLUSION

In this paper, we discussed the radiation effects on the unsteady MHD free convection flow past in an infinite vertical plate with heat source has been studied. The governing equations are solved for the velocity field & temperature by using perturbation technique in terms of dimensionless parameters. In this analysis, the following conclusions set out:

i. The velocity increases with an increase the porous parameter (K).
ii. The velocity decreases with an increase the oscillating frequency ($\omega$), suction parameter (S), radiation parameter (R) & Prandtl number (Pr).
iii. The velocity decreases near to the plate & then increases away from the plate with an increase the magnetic parameter (M).
iv. The temperature falls with increases of the suction parameter (S), Prandtl number (Pr), oscillating parameter ($\omega$) & radiation parameter (R).
v. The skin friction increases with the increase of suction parameter (S) & Prandtl number (Pr), radiation parameter (R), magnetic parameter (M), porous parameter (K) & thermal Grashof number (Gr).
vi. The skin friction decreases with the increase of oscillating frequency ($\omega$).
vii. The Nusselt number increases with the increase of radiation parameter (R) & oscillating parameter ($\omega$).
viii. The Nusselt number decreases with the increase of suction parameter (S) & Prandtl number (Pr).

## REFERENCES


[1] Mansour, M.A., Radiation and free convection effects on the oscillatory flow past a vertical plate, Astrophysics and Space Science, 166, 1990, pp.269-275.

[2] Vajravelu, K., Hadjinicolaou, A., Heat transfer in a viscous fluid over a stretching sheet with viscous dissipation and internal heat generation, *Int, Comm. Heat Mass Transfer*,20,1993,pp.417-430.

[3] Soundalgekar, V. M., Das, U. N. and Deka, R. K., Free convection effects on MHD flow past an infinite vertical oscillating plate with constant heat flux, Indian J. Math, 39(3), 1997,pp. 195-202.

[4] Helmy, K. A., MHD unsteady free convective flow past a vertical porousplate. ZAMP, Z. Angew Math. Mech., 78(4), 1998, pp. 255-270.

[5] Hossain, M. A., Das, S.K. and Pop, I., Heat transfer response of MHD free convective flow along a vertical plate to surface temperature oscillation,, Int. J. Non-Linear Mech., 33(3), 1998,pp. 541-553.

[6] Kim, Y. J., Unsteady MHD convective heat transfer past a semi-infinite vertical porous moving plate with variable suction, Int. J. Eng. Sci., 38, 2000, pp.833-841.

[7] Abd El-Naby, M. A., Elbarbary, E. M. E. and Abdelazem,N. Y., Finite difference solution of radiation effects on MHD unsteady free-convection flow over vertical plate with variable surface temperature. J. Appl. Math., 2, 2003, pp. 65-86.

[8] Zhang, X. R., Mauryaama, S. and Sakai, S., Numerical investigation of laminar natural convection on a heated vertical plate subjected to a periodic oscillation. Int. J. Heat and Mass transfer, Int. J. Heat and Mass transfer, 47(19-20), 2004, pp. 4439-4448.

[9] Pathak, G., Maheshwari, C. H. and Gupta, S.P., Effects of radiation on unsteady free convection flow bounded by an oscillating plate with variable temperature, IJAME, 11(2), 2006, pp. 371-382.

[10] Chandrakala, P. and Antony Raj, S., Radiation effects on MHD flow past an implusively started vertical plate with uniform heat flux, Indian J. Math, 50(3),2008, pp.519-532.

[11] Chandrakala, P. and Bhaskar, P.N., Thermal radiation effects on MHD flow past a vertical oscillating plate. Int. J. Appl. Mech. Engg., 14(2), 2009, pp.349-358.

[12] Kumar, H., Radiative Heat transfer with hydro magnetic flow and viscous dissipation over a stretching surface in the presence of variable heat flux Thermal Science,13(2),2009,pp.163-169.

[13] Toki, C.J., Unsteady free convection flow on a vertical oscillating porous plate with constant heating. Journal of Applied Mechanics, 76(1), 2009, pp.4-12.

[14] Anjali Devi, S. P., Ganga, B., Dissipation effect on MHD flow and heat transfer past a Porous surface with prescribed heat flux, Journal of Applied flux Mechanics, 3, 2010, pp.1-6.

[15] Rani, K. J. and Murthy, Ch.V. R., MHD flow over a moving infinite vertical porous plate with uniform heat flux in the presence of thermal radiation. Adv. Theor. Appl. Math, 6(1), 2011, pp.51-63.

[16] Manna, S.S., Das, S. and Jana, R. N., Effects of radiation on unsteady MHD free convective flow past an oscillating vertical porous plate embedded in a porous medium with oscillatory heat flux. Advances in Applied Science Research, 3(6), 2012, pp.3722-3736.

[17] Senapati, N., Das, T.K. and Dhal, R.K., Radiation effects of MHD free convective heat transfer past an oscillating hot vertical surface in porous, J. of the Orissa math, 31(2), 2012, pp.77-90.

[18] Ahmad, F., Hussain, S., Ali, M., Analytical solution of MHD flow over stretching porous sheet, J. Basic. Appl. Sci. Research, 4(3), 2014, pp.160-167.

[19] Ahmad F., Hussain, S., Alanbari, A. M. and Alharbi, R.S., MHD flow and heat transfer through a porous medium over a stretching/shrinking surface with suction, Sci. Int.(Lahore),27(2),2015,pp.931-935.

[20] Sai, E.R. and Murthy, Ch.V.R., MHD flow over a moving infinite vertical porous plate with uniform heat flux in the presence of thermal radiation, Int. J. of Math. Archives, 9(5), 2018, pp.22-30.

[21] Pai, S.I., Viscous flow theory: I-Laminar flow, D. Van Nostrand Co.New York, U.S.A.,1956.

[22] Jeffery, A., Magnetohydrodynamics, Oliver and Boyed, New York, U.S.A., 1966.
[23] Bansal, J.L., Viscous fluid dynamics, Oxford & IBH Pub.Co., New Delhi, India, 1977.
[24] Bansal, J. L., Magnetofluiddynamics of viscous fluids, Jaipur Pub. House, Jaipur, India, 1994
[25] Schlichting, H., Gersten, K., Boundary layer theory, McGraw-Hill book Co. New York, U.S.A.,1 999.

.