International Journal of Mathematical Archive-10(4), 2019, 53-57
Available online through www.ijma.info ISSN 2229 – 5046

MHD CONVECTIVE FLOW OVER A VERTICAL SURFACE WITH RESPECT TO POROSITY AND MASS DIFFUSION

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(Received On: 28-10-18; Revised & Accepted On: 07-04-19)

ABSTRACT

The influence of critical parameters on the velocity of fluid medium in case of MHD convective flow over a vertical surface with respect to porosity and mass diffusion has been studied in this paper. It is observed that, as the magnetic intensity increases, the velocity of the fluid decreases and also, as Prandtl number increases, the velocity increases. Further, it is seen that as we move far away from the boundary, the velocity increases. In addition to the above, it is observed that, as Schmidt number increases, the velocity of the fluid decreases. Also, as magnetic intensity increases, the fluid velocity decreases. It is noticed that, as the smith number increases, the velocity decreases. Though there is a significant change in the Schmidt number, not much of appreciable change in the velocity profile is noticed.

Key words: *Heat and Mass transfer, Radiation, skin friction.*

INTRODUCTION

A detailed attention has been paid on the study of boundary layer behavior and heat transfer phenomena of a Newtonian fluid which embedded in fluids saturated porous medium. The problem has extensive applications in wide ranging areas of science engineering and technology. The problem has significant applications in Physics, Chemistry and Chemical Technology due to demanding efficient transfer of mass on inclined beds and viscous flow nature.

The engineering applications include reaction in a reaction chamber, chemical vapor deposition on the surfaces of a reactor etc. The problem of combined heat and mass transfer was studied in detail by Chienhsin-Chen [1]. Thereafter, Ghaly *et.al* [2] examined the problem and established that, at high operating temperature, radiation effects are quiet significant. Later, Hossain [3] and Takhar [4] examined the radiation effects on free and forced convection flows past a vertical plate. Subsequently, Muthukumarswamy *et.al* [5] examined the heat and mass transfer effects on a moving plate in the presence of thermal radiation.

MATHEMATICAL FORMULATION

The geometry is considered to be x*-axis is taken along the plate. y*-axis is considered to be perpendicular to x* axis and transverse constant magnetic field is applied in the direction of y*-axis. The length of the plate is considered to be sufficiently large so that the variables are independent of x*. Further, u* and v* are considered to be velocity components in the x* and y* directions respectively. The equations of continuity, momentum and energy in the presence of concentration and radiation as follows.

$$\frac{dv^*}{dy^*}=0 \tag{1}$$

i.e $v^*=-v_0$ (constant) (2)

$$\rho v^*\frac{du^*}{dy^*}=\mu\frac{d^2u^*}{dy^{*2}}+\rho g\beta(T^*-T_\infty)-\sigma B_0{}^2u^*+\rho g\beta^*(C^*-C_\infty) \tag{3}$$

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$$\rho C_p v^* \frac{dT^*}{dy^*} = K \frac{d^2T^*}{dy^{*2}} + \mu \left(\frac{du^*}{dy^*}\right)^2 - \frac{\partial q^*_r}{\partial y^*} + \sigma B_0{}^2 u^* \tag{4}$$

$$v^* \frac{dC^*}{dy^*} = D \frac{d^2C^*}{dy^{*2}} \tag{5}$$

Here, g is the acceleration due to gravity, T^* the temperature of the fluid near the plate, T_∞ the free stream temperature, C^* concentration, β the coefficient of thermal expansion, κ the thermal conductivity, p^* the pressure, C_p the specific heat of constant pressure, B_0 the magnetic field coefficient, μ viscosity of the fluid, qr^* the radioactive heat flux, ρ the density, σ the magnetic permeability of fluid V_0 constant suction velocity, ν the kinematic viscosity and D molecular diffusivity.

The boundary conditions are

$$y^* = 0: u^*=0, T^*=T_w, C^\infty=C, y^* \to \infty: u^* \to 0, T^* \to T_\infty, C^* \to C_\infty \tag{6}$$

Introducing the following non-dimensional quantities

$$y = \frac{v_0 y^*}{v}, \; u = \frac{u^*}{v_0}, \; M^2 = \frac{B_0{}^2 v^2 \sigma}{v_0{}^2 \mu} \tag{7}$$

$$P_r = \frac{\mu C_p}{K}, \; \theta = \frac{T^* - T_\infty}{T_w - T_\infty}, C = \frac{C^* - C_\infty}{C - C_\infty} \tag{8}$$

$$E = \frac{V_0{}^2}{C_p(T_w - T_\infty)} \tag{9}$$

$$G_r = \frac{\rho g \beta v^2 (T_w - T_\infty)}{v_0{}^3 \mu} \tag{10}$$

$$S_c = \frac{v}{D}, \; Gm = \frac{\rho g \beta^* (C - C_\infty)}{v_0{}^3} \quad \text{and} \quad F = \frac{4vI}{\rho C_p V_0{}^2} \tag{11}$$

$$\frac{d^2u}{dy^2} + \frac{du}{dy} - M^2 u = -G_r \theta - G_m C + \frac{\mu}{K} \tag{12}$$

$$\frac{d^2\theta}{dy^2} + \Pr \frac{d\theta}{dy} - F \Pr \theta = 0 \tag{13}$$

$$\frac{d^2C}{dy^2} + S_C \frac{dC}{dy} = 0 \tag{14}$$

where,

G_r = Grashoff number,

P_r = Prandtl number,

M = Magnetic parameter,

F = Radiation parameter,

S_r = Schmidt number,

E= Eckert number.

K_1 = porosity of fluid bed

The respective boundary condition in the dimensionless form are given to be

$$y=0: u=0, \theta=1, C=1, y \to \infty: u \to 0: \theta \to 0. \tag{15}$$

Let $u = u_0(y) e^{iwt}$, $\theta = \theta_0(y) e^{iwt}$, $C = C_0(y) e^{iwt}$

Be the trial solution for the solution of for solving equation (12), equation (13) and equation (14).

Solving the above set of equations, we get

$$U = \frac{1}{m_2{}^2 - m_2 - (M^2 + 1/K)} G_r [e^{m_4 y} - e^{-m_2 y}] + \frac{1}{s_C{}^2 - s_c - (M^2 + 1/K)} G_m [e^{m_4 y} - e^{s_c y}]$$

$$+ \frac{1}{(M^2 + 1/K)} G_m [1 - e^{m_4 y}]$$

$$\theta = e^{-m_2 y}$$

$$C = 1 - e^{-S_c y}$$

where,

$$m_1 = \left[\frac{-P_r + \sqrt{P_r^2 + 4P_r F}}{2} \right]$$

$$m_2 = -\left[\frac{P_r + \sqrt{P_r^2 + 4P_r F}}{2} \right]$$

$$m_3 = \left[\frac{-1 + \sqrt{P_r^2 + 4\left(M^2 + \frac{1}{K} \right)}}{2} \right]$$

$$m_4 = -\left[\frac{-1 + \sqrt{P_r^2 + 4\left(M^2 + \frac{1}{K} \right)}}{2} \right]$$

RESULTS AND CONCLUSIONS

1. The effect of Magnetic field for a constant value of Prandtl number is illustrated in figure-1. It is observed that as the magnetic intensity increases, the velocity of the fluid decreases.
2. Fig 2 depicts the influence of Prandtl number on the velocity profiles for a fixed value of Magnetic intensity. It is noticed that as Prandtl number increases, the velocity increases. Further, it is observed that as we move far away from the boundary, the velocity increases.
3. The effect of schmidt number on the velocity profiles for constant value of magnetic intensity is shown in fig 3. It is noticed that as schmidt number increases, the velocity of the fluid decreases.
4. The influence of magnetic intensity for a constant value of Prandtl number over the velocity profiles is shown in figures 4, 5 and 6. It is noticed that, as magnetic intensity increases, the fluid velocity decreases.
5. The consolidated influence of porosity with respect to smith number on the velocity fluid illustrated in figure 7. It is observed that, as porosity increases, the velocity decreases.
6. The influence of the schmidt number w.r.t to the porosity on the velocity is shown in figures8 and 9. It is noticed that, as the smith number increases, the velocity decreases. Though there is a significant change in the smith number, not much of appreciable change in the velocity profile is noticed.

FIGURES:

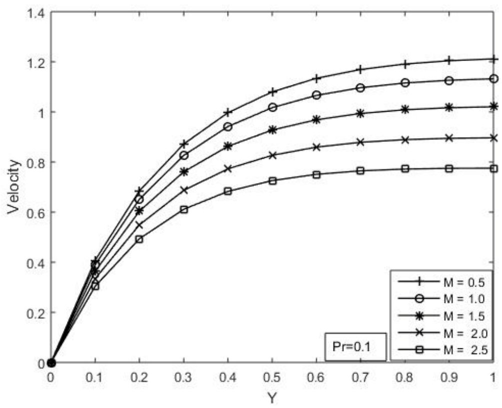

Figure – 1: Variation of velocity profiles with respect to applied Magnetic field

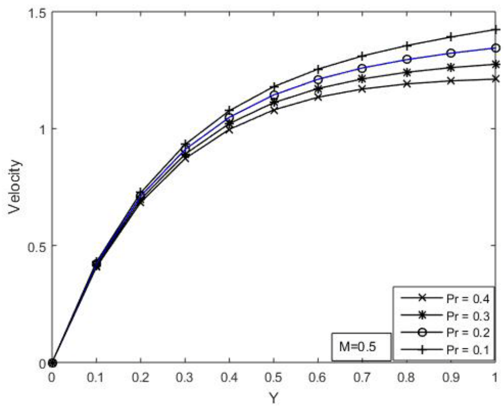

Figure – 2: Variation of velocity profiles with respect to Pr

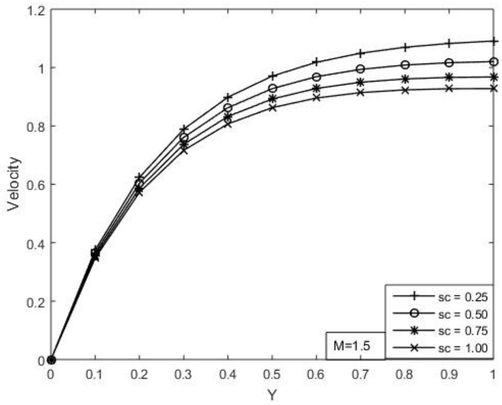

Figure – 3: Variation of velocity profiles with respect to sc

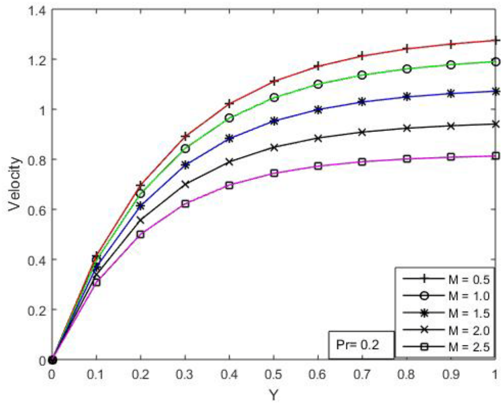

Figure – 4: Variation of velocity profiles with respect to applied Magnetic field

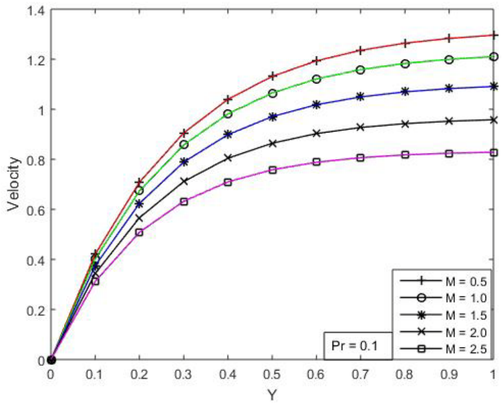

Figure – 5: Variation of velocity profiles with respect to applied Magnetic field

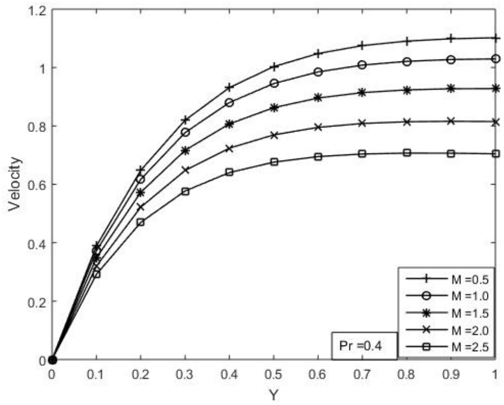

Figure – 6: Variation of velocity profiles with respect to applied Magnetic field

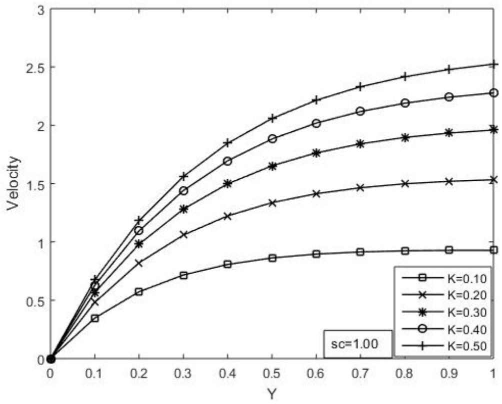

Figure -7: Variation of velocity profiles with respect to Porosity

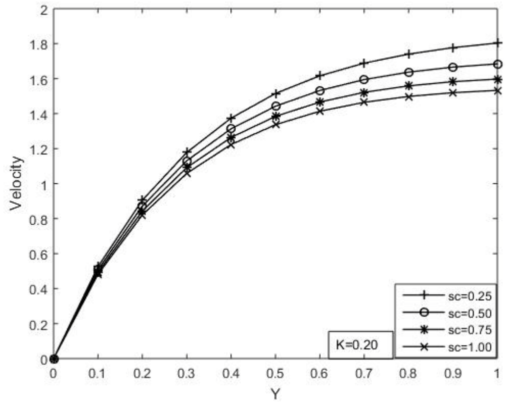

Figure 8: Variation of velocity profiles with respect to Sc

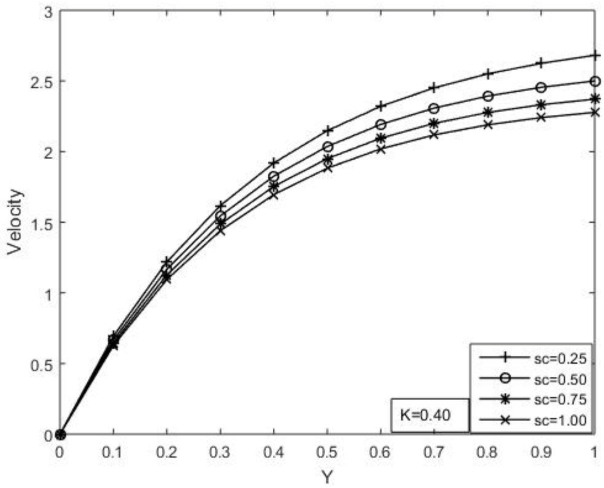

Figure -9: Variation of velocity profiles with respect to Sc

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Source of support: Nil, Conflict of interest: None Declared.