EFFECT OF CHEMICAL REACTION ON MHD FLOW OF CONTINUOUSLY MOVING FLUID IN A POROUS VERTICAL SURFACE WITH UNIFORM HEAT AND MASS FLUX

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ABSTRACT

In this paper solution for effect of chemical reaction on MHD flow of convection over a continuously moving vertical surface with uniform suction through porous medium is obtained. Flow of this kind represents a new class of boundary-layer flow at a surface of finite length. The solution for the velocity , and concentration profiles are obtained. The expressions for velocity distribution, temperature and concentration distribution are discussed numerically and shown through graphs. Key Words:Heat transfer, MHD; Heat and mass flux

Introduction:

Sakiadis [1] studied the growth of the two-dimensional velocity boundary layer over a continuously moving flat plate. Vajravelu [2] studied the exact solutions for hydrodynamic boundary layer flow and heat transfer over a continuous, moving, horizontal fat surface with uniform suction and internal heat generation/absorption. Again, Vajravelu [3] extended the problem [2] to a vertical surface.The problem of MHD laminar flow through a porous medium has become very important in recent years particularly in the field of agriculture. The magneto hydrodynamic flow has various applications in designing, cooling systems, petroleum industry, purification of crude oil, polymer solutions etc. The flow through porous media have numerous engineering and geophysical applications, for example, in the field of agriculture engineering to study the underground water resources, in purification processes in petroleum technology to study the movement of natural gas, oil and water through the oil channels/reservoirs etc. The magneto hydrodynamics of electrically conducting fluids in the presence of magnetic field is encountered in many important problems in Geophysics and Astrophysics. There has been a renewed interest in studying magneto-hydrodynamic (MHD) flow and heat transfer aspects in various geometries due to the effect of magnetic fields on the flow control and on the performance of many systems using electrically conducting fluids such as liquid metals, water mixed with little acid and others. Chakrabarti and Gupta [17] considered hydro magnetic flow and heat and mass transfer over a stretching sheet. Vajravelu and Hadjinicolaou [18] reported on convective heat transfer in an electrically conducting fluid at stretching surface with uniform free stream. Other examples of studies dealing with hydro magnetic flows can be found in the papers by Gray [19], Michiyoshi *et al.* [20], and Fumizawa [21]. Muthucumaraswamy [9] has been studied hydro magnetic flow and heat transfer on a continuously moving vertical surface.Yamammoto Iwamura [4] expressed the equations of flow through a highly porous medium under the influence of temperature differences. Raptis and Pardikis [5] analyzed the free convective flow through a highly porous media bounded by an infinite porous plate with constant suction when the free stream velocity oscillates about a mean constant value.

In above studies the investigators have restricted themselves to two dimensional flows, but may arise situations where the flow fields may be essentially three dimensional. Singh et al. [6] and [7] have investigated the three dimensional convective flow and heat transfer in presence of viscous dissipative heat. Further Singh [8] studied the effect of a uniform magnetic field applied normal to the free convection flow of an electrically conducting viscous incompressible fluid past an infinite vertical porous plate with a slightly sinusoidal transverse suction velocity distribution. Kumari et al. [9] studied flow and heat transfer of a visco-elastic fluid over a flat plate with a magnetic field and a pressure gradient .Ahmed and Sharma [10] discussed the problem of three dimensional free convective flow of an incompressible viscous fluid through a porous medium with free stream velocity.

The free convection flow through a porous medium bounded by a vertical porous plate with constant suction when the free stream velocity oscillates in time with a constant mean value was investigated by Raptis and Perdikis [11]. Nelson and Wood [12] have presented numerical analysis of developing laminar flow between vertical parallel plates for combined heat and mass transfer natural convection with uniform wall temperature and concentration boundary conditions. Trevison and Bejan [13] have analyzed natural convection heat and mass transfer through a vertical porous layer subjected to uniform flow of heat and mass from the side. The flow is driven by the combined buoyancy effect due to temperature and concentration variation through the porous medium. Singh and Rakesh Sharma [14] have investigated the transverse periodic variation of permeability on heat transfer and free convective flow of a viscous incompressible fluid through a highly porous medium bounded by a vertical porous plate.

The study of stellar structure on solar surface is connected with mass transfer phenomena. Its origin is attributed to difference in temperature caused by the non-homogeneous production of heat which in many cases can rest on only in the formation of convective currents but also in violent explosions. Mass transfer certainly occurs within the mantle and cores of plates of the size of or larger than the earth. In the present study we therefore, propose to analyze the effect of mass transfer on unsteady free convective flow of a viscous incompressible electrically conducting fluid past on infinite vertical porous platewith constant suction and heat source in presence of a transverse magnetic field.T. Sankar Reddy et al [15] studied heat and mass transfer effects on MHD flow of continuously moving vertical surface with uniform heat and mass flux. Ruchi Chaturvedi et al. [16] have studied the analytical solutions of heat and mass transfer effects on MHD flow of convection over a continuously moving vertical surface with uniform suction through porous medium. The purpose of the present paper is to obtain the solution of heat and mass transfer effects on MHD flow of convection over a continuously moving vertical surface with uniform suction through porous medium with effect of chemical reaction for single phase flow.

Formulation of the Problem:

Consider the steady, two-dimensional, laminar, incompressible flow of a viscous fluid on a continuously moving vertical surface in the presence of a uniform magnetic field, uniform heat and mass flux effects, issuing a slot and moving with uniform velocity uw in a fluid at rest. Let the x-axis be taken along the direction of motion of the surface in the upward direction and y-axis is normal to the surface. The temperature and concentration levels near the surface are raised uniformly. The induced magnetic field, viscous dissipation are assumed to be neglected. Now, under the usual Boussinesq's approximation, the flow field is governed by the following equations.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad \dots (1)$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} + g\beta(T' - T'_\infty) + g\beta(C' - C'_\infty) - \frac{\sigma B_0^2 u}{\rho} - \frac{\upsilon u}{K'} \quad \dots (2)$$

$$\mu c_p\left(u\frac{\partial T'}{\partial x} + v\frac{\partial T'}{\partial y}\right) = k\frac{\partial^2 T'}{\partial y^2} \quad \dots (3)$$

$$u\frac{\partial C'}{\partial x} + v\frac{\partial C'}{\partial y} = D\frac{\partial^2 C'}{\partial y^2} - S(C' - C'_\infty) \quad \dots (4)$$

The initial and boundary conditions are :

$$u = u_w, v = v_0 = \text{const.} < 0, \frac{\partial T'}{\partial y} = -\frac{q}{k}, \frac{\partial C'}{\partial y} = \frac{j'}{D} \text{ at } y = 0$$

$$u \to 0, T' \to T'_\infty, C' \to C'_\infty \text{ as } y \to \infty \quad \dots (5)$$

We now introduce the following non-dimensional quantities:

$$Y = \frac{v_0 y_0}{\nu}, U = \frac{u}{u_w}, T = \frac{T' - T'_\infty}{\left(\frac{q\nu}{kv_0}\right)}, Gr = \frac{g\beta y\left(\frac{q\nu}{kv_0}\right)}{u_w v_0^2}, Gc = \frac{g\beta^* \nu\left(\frac{j'\nu}{kv_0}\right)}{u_w v_0^2}, \quad \dots (6)$$

$$C = \frac{C' - C'_\infty}{\left(\frac{j'\nu}{kv_0}\right)}, \Pr = \frac{\mu c_p}{k}, Sc = \frac{\nu}{D}, M = \frac{\sigma B_0^2 \nu}{\rho v_0^2} K = \frac{K'\upsilon}{v_0^2}, S' = \frac{S\nu}{v_0}$$

In view of Equation (6), the governing Equations (2)-(4) reduce to the following non-dimensional form:

$$\frac{d^2 U}{dY^2} - \frac{dU}{dY} + Gr\,T + Gc\,C - \left(M + \frac{1}{K}\right)U = 0 \quad \dots (7)$$

$$\frac{d^2T}{dY^2} - \Pr\frac{dT}{dY} = 0$$

… (8)

$$\frac{d^2C}{dY^2} Sc\frac{dC}{dY} + S'C = 0$$

… (9)

The corresponding initial and boundary conditions in non-dimensional form are:

$$U = 1, \frac{\partial T}{\partial Y} = -1, \frac{\partial C}{\partial Y} = -1 \quad \text{at} \quad Y = 0$$

$$U \to 0, T \to 0, C \to 0 \quad \text{at} \quad Y = 0$$

… (10)

Where **Gr, Gc, Pr, Sc and S’** are the thermal Grashof number, solutal Grashof number, magnetic parameter, Prandtl number , Schmidt number and chemical reaction parameter respectively.

3. SOLUTION OF THE PROBLEM

Solving Equations (7)-(9) with boundary conditions (10), we get,

$$U = C_5e^{mY} + C_6e^{nY} + P + Be^{\Pr Y} + Qe^{FY} - Le^{GY}$$

… (11)

$$T = \frac{1}{\Pr}(1 - \exp(\Pr Y))$$

… (12)

$$C = -\frac{(e^{FY} - e^{GY})}{E}$$

…(13)

Where

$$E = \sqrt{Sc^2 - 4S'}$$

$$F = (Sc + E) / 2,$$

$$G = (Sc - E) / 2$$

$$H = M + 1 / K$$

$$P = Gr / \Pr.H$$

$$A = \frac{-Gr}{\Pr\left(\Pr^2 - \Pr - \left(M + \frac{1}{K}\right)\right)}$$

$$B = \frac{-Gr}{\Pr\left(\Pr^2 - \Pr - H\right)},$$

$$Q = \frac{-Gc}{E\left(F^2 - F - H\right)},$$

$$B = \frac{-Gc}{E\left(G^2 - G - H\right)},$$

$$C_5 = -(C_6 + P + B + Q - L)$$

$$C_6 = \frac{(1 + (P + B + Q - L)m - B.Sc - Q.F + LG)}{(n - m)},$$

$$m = \frac{(1 + \sqrt{1 + 4H})}{2},$$

$$n = \frac{(1 - \sqrt{1 + 4H})}{2}$$

Knowing the velocity field, the skin-friction are given as :

$$C_f = \frac{\tau'}{\rho u_w v_0} = -\left(\frac{dU}{dY}\right)_{Y=0}$$

Results and Discussion:

In the preceding sections, analytical solutions for the problem of heat and mass transfer by steady flow of an electrically conducting in the presence of uniform heat and mass flux. The expressions for the velocity, temperature and concentration were obtained.

Figure 1 shows the fluid velocity profiles against span wise coordinates for different values of Porous parameter K. Initially It is observed upto a certain value of Y velocity remains unchanged but after this for an increase in porous parameter K there is decrease in the fluid velocity.

In Fig. 2 depicts the effect of chemical reaction parameter on the velocity profiles against span wise coordinate *y*. It is observed that the velocity decreases with decrease in porous parameter K.

It is observed that there is no effect of porous parameter K on concentration. **(Figure-3).**

The effect of the concentration profiles against span wise coordinate *y* for different values of chemical reaction parameter. It is observed that the concentration decreases with increasing values the Schmidt number **(Figure-4).**

Conclusions:

Analytical solutions of heat and mass transfer effects on MHD flow of convection over a continuously moving vertical surface with uniform suction through porous medium is obtained.

The obtained results were compared with the previous works and were found to be in good agreement. The study concludes the following results:

It is observed that an increase in K leads to decrease in the velocity

It is observed that as increase in *M* leads to decrease in the velocity.

It is observed that the temperature increases with decreasing values of *Pr* the Prandtl number.

It is observed that the concentration decreases with increasing values of Sc Schmidt number.

It is observed that an increase in *Gr* leads arise in the values of velocity.

Figures:

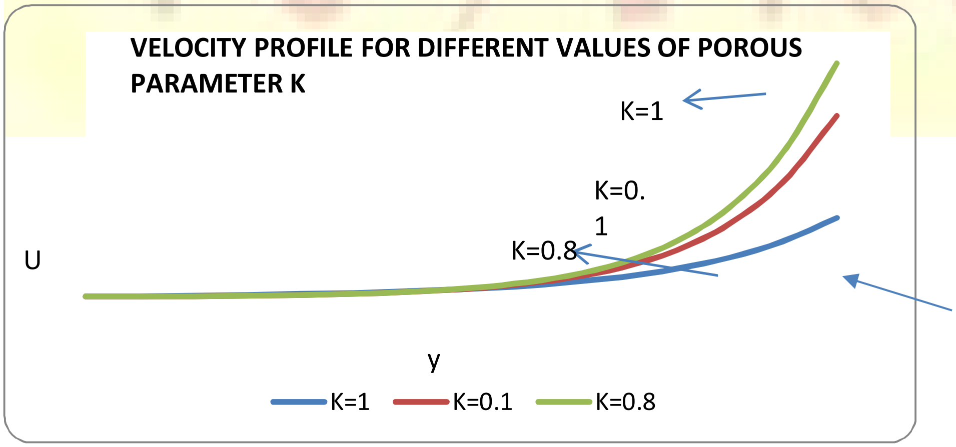
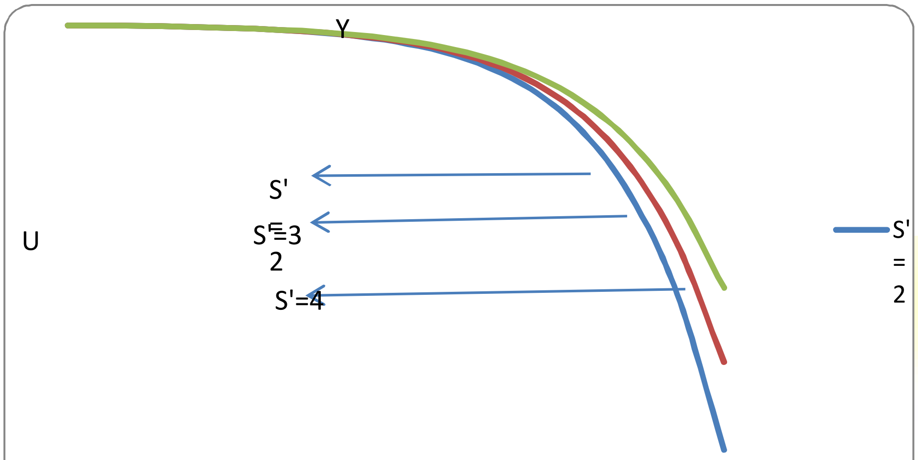
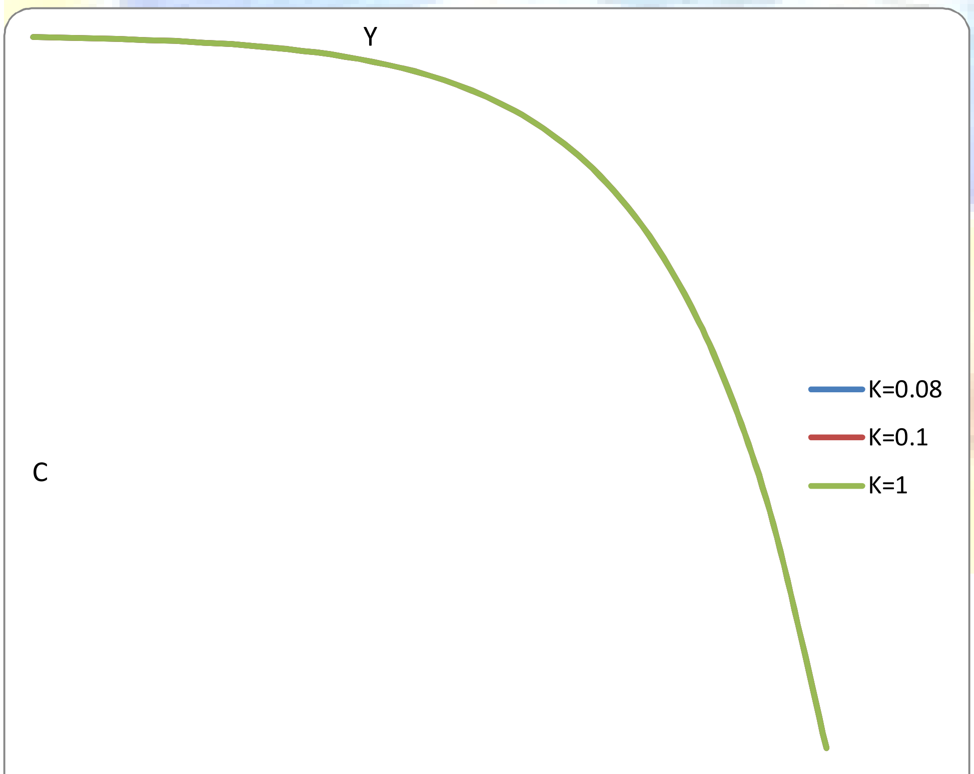


FIG: 1



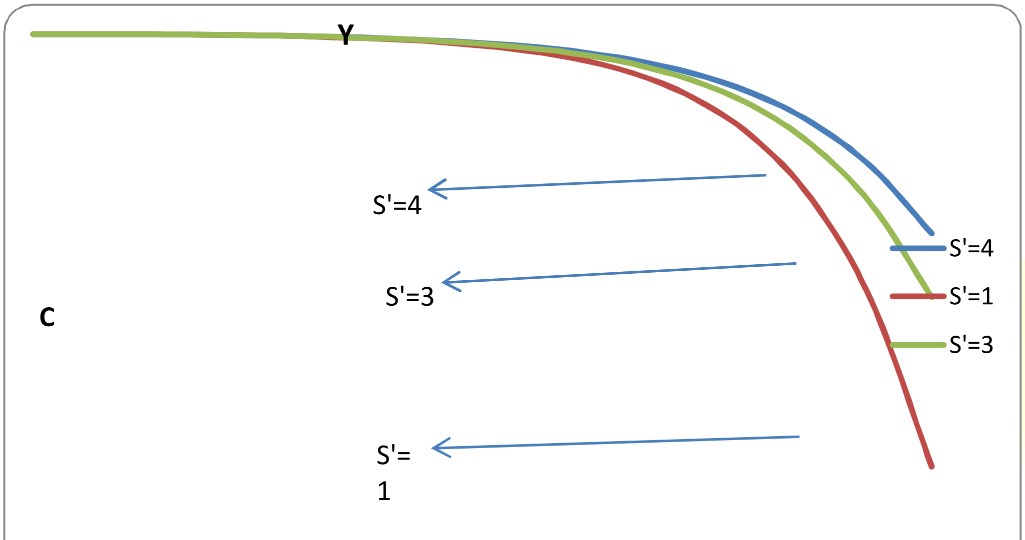
VELOCITY PROGFILE FOE DIFFERENT VALUES OF S'(CHEMICAL REACTION PARAMETER

FIG:2



EFFECT OF POROUS PARAMETER ON CONCENTRATION

FIG: 3



EFFECT OF CHEMICAL REATION PARAMETER ON CONCENTRATION

FIG:4

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