# Mhd Flow Of Continuously Moving Fluid In A Vertical Surface With Uniform Heat And Mass Flux Through Porous Medium And It's Application In Real World

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***Abstract*— In present time people from science and technology are continuously making new innovations and updating the previous models of Mathematics on applications of Mathematical fundamentals in real life, So a very important application is application of Mathematical modeling in biosciences. In this paper we have discussed applications of Porous media in plants.**

***Index Terms*— Mathematics, Mathematical modeling, Porous media**

## I. Introduction

The understanding of multiphase and single phase flow in porous media is of great importance in many fields such as hydrology, contaminant clean-up and petroleum engineering. Macroscopic properties—principally capillary pressure and relative permeability—are often needed when modeling flow and transport at the continuum scale, whether it is transport of non-aqueous phase liquids (NAPL) in contaminant clean-up or the production of oil during reservoir water flooding. These macroscopic properties are, however, difficult to obtain. It is possible to conduct physical experiments on samples of the reservoir, but this will only reflect one set of conditions.

Mathematical modeling of transport processes in porous media is a powerful tool employed whenever experimentation is either expensive or difficult due to the nature of the process. On the other hand, the realistic description of the porous structure significantly increases the complexity of the mathematics involved, due to the coupling between the physicochemical mechanisms and the geometrical complexity of the porous medium, thus requiring massive computational power.

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.

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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. Atul Kumar Singh *et al.*, [15] discussed the effect of permeability variation and oscillatory suction velocity on free convective heat and mass transfer flow of viscous incompressible fluid past an infinite vertical porous plate. Chitti Babu and Prasada Rao [16] studied the effect of transverse periodic variation of the permeability on the heat and mass transfer and the free convective flow of a viscous incompressible fluid through a highly porous medium bounded by an infinite vertical plate.

Motivated by various applications of flows through a porous medium, Nelson D.J. [12] had extended the work of Chitti babu and Prasada Rao [16] to study the flow of viscous incompressible electrically conducting fluid through a highly porous medium bounded by an infinite vertical porous medium and by an infinite vertical porous plate with constant suction.

T. Sankar Reddy et al [23] studied heat and mass transfer effects on MHD flow of continuously moving vertical surface with uniform heat and mass flux. Ruchi Chaturvedi et al [24] reported the analytical solutions heat and mass transfer effects on MHD flow of convection over a continuously moving vertical surface with uniform suction through porous medium.

## II. FORMULATION OF THE PROBLEM

We have taken 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 $u_w$ 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 is assumed to be neglected. Now, under the usual Boussinesq's approximation, the flow field is governed by the following equations.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

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

… (2)

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

$$u\frac{\partial C'}{\partial x} + \frac{\partial C'}{\partial y} = D\frac{\partial^2 C'}{\partial y^2}$$

The initial and boundary conditions are:

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

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

We now introduce the following non-dimensional quantities:

$$Y = \frac{yy_0}{v}, U = \frac{u}{u_w}, T = \frac{T' - T'_\infty}{\left(\frac{qv}{kv_0}\right)}, Gr = \frac{g\beta y\left(\frac{qv}{kv_0}\right)}{u_w v_0^2}, Gc = \frac{g\beta^* v\left(\frac{j'v}{kv_0}\right)}{u_w v_0^2},$$

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

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

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

… (1)

$$\frac{d^2T}{dY^2} + \Pr\frac{dT}{dY} = 0 \quad \ldots (8)$$

$$\frac{d^2C}{dY^2} + Sc\frac{dC}{dY} = 0 \quad (9)$$

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

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

$$U \to 0, T \to 0, C \to 0 \quad \text{at} \quad Y = 0 \quad (10)$$

Where Gr, Ge, Pr and Sc are the thermal Grashof number, solutal Grashof number, magnetic parameter, Prandtl number and Schmidt number respectively.

## III. SOLUTION OF THE PROBLEM

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

$$U = (1-(A+B))\exp(-mY) + A\exp(-\Pr Y) \div B\exp(-ScY)$$
… (11)

$$T = \frac{1}{\Pr}(\exp(-\Pr Y)) \quad (12)$$

$$C = \frac{1}{Sc}(\exp(-ScY)) \quad (13)$$

Where $m = \frac{1}{2}\left(1 + \sqrt{1 + 4\left(M + \frac{1}{K}\right)}\right)$

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

$$B = \frac{-Gc}{Sc\left(Sc^2 - Sc - \left(M + \frac{1}{K}\right)\right)}$$

Knowing the velocity field, the skin-friction are given as: $C_f = \frac{\tau}{\rho u_w v_0} = -\left(\frac{dU}{dY}\right)_{Y=0}$

$$= (1-(A+B))\left(M + \frac{1}{K}\right) + A\Pr + B\,Sc$$

## IV. CONCLUSIONS

Analytical solutions for the problem of heat and mass transfer of 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.

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:

1. It is observed that an increase in K leads to decrease in the velocity
2. It is observed that as increase in *M* leads to decrease in the velocity.
3. It is observed that the temperature increases with decreasing values of *Pr* the Prandtl number.
4. It is observed that the concentration decreases with increasing values of Sc Schmidt number.
5. It is observed that an increase in *Gr* leads arise in the values of velocity.

## V. FIGURES:

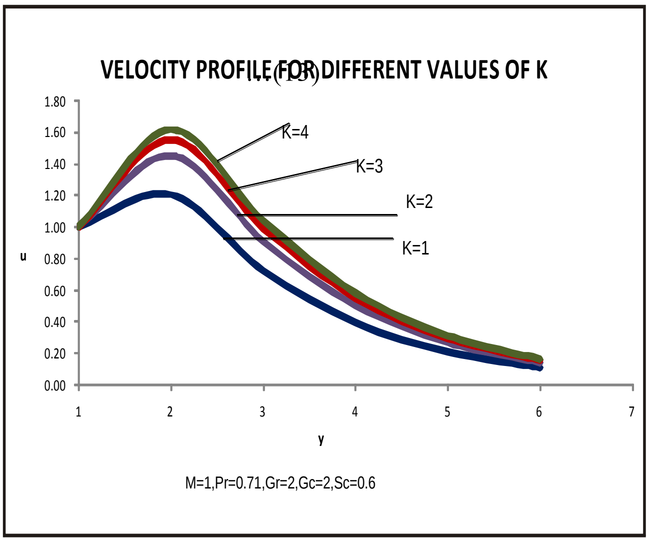



FIG.-1

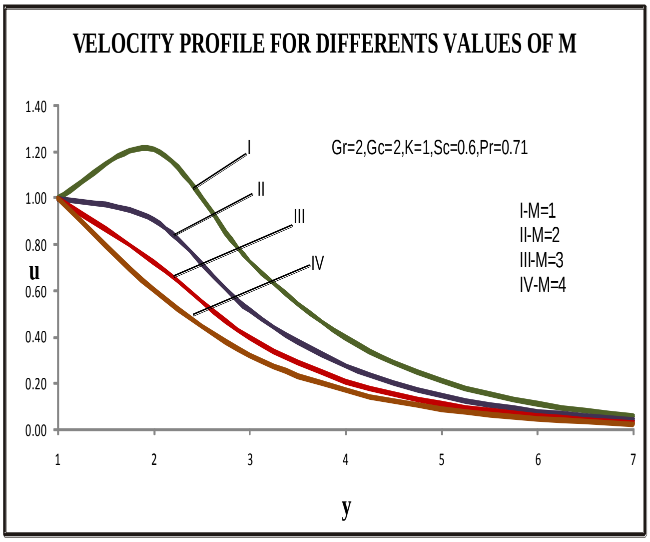



FIG.-2

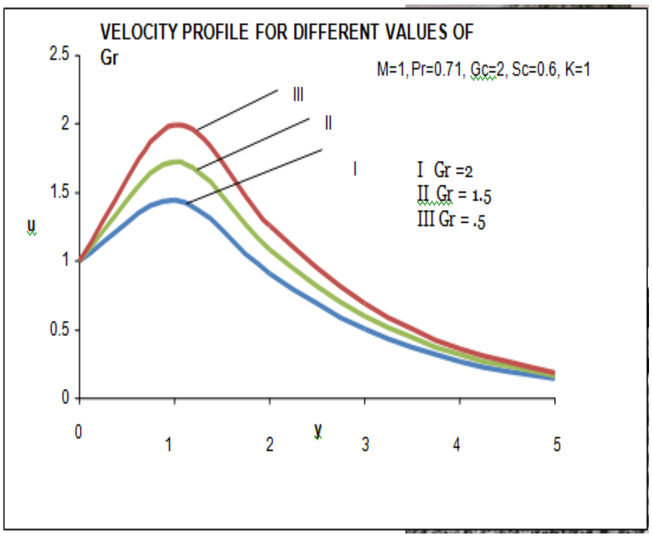



FIG.-5

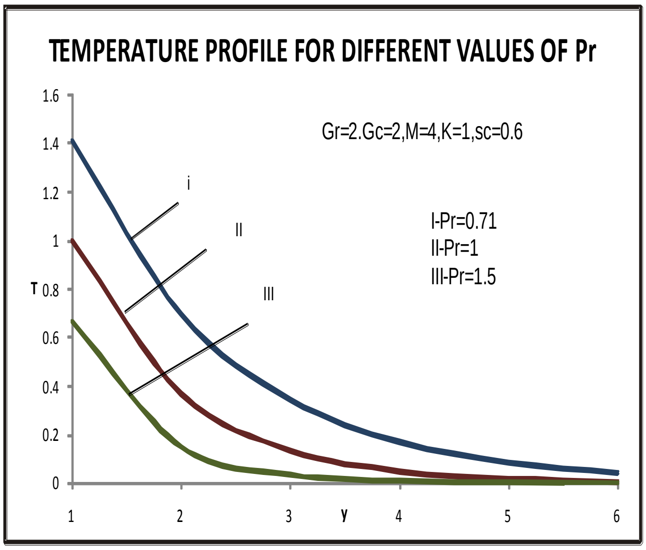



FIG.-3

## VI. FLOW THROUGH POROS MEDIA:

The analysis of fluid flow in porous media is required in a large range of applications. The porous media can be naturally formed (e.g. rocks, sand beds, sponges, woods) of fabricated (e.g. catalytic, pellets, wicks, insulations.The applications are in the area of chemical, environmental, mechanical and petroleum engineering and in geology. As expected, the range of pore sizes or particle sizes (when considering the solid matrix to be made of consolidated or nonconsolidated particles) is vast and cen be of the order of molecular size (ultrasmicropores with 3<d<7A° where d is the average pore size), the order of centimeters (e.g. pebbles, food stuff, debris), or larger. Figure 6, gives a classification of the particle size based on measurement technique, application and statistics. A review of the particle characteristics for particles with diameters smaller than 1 cm is given by .

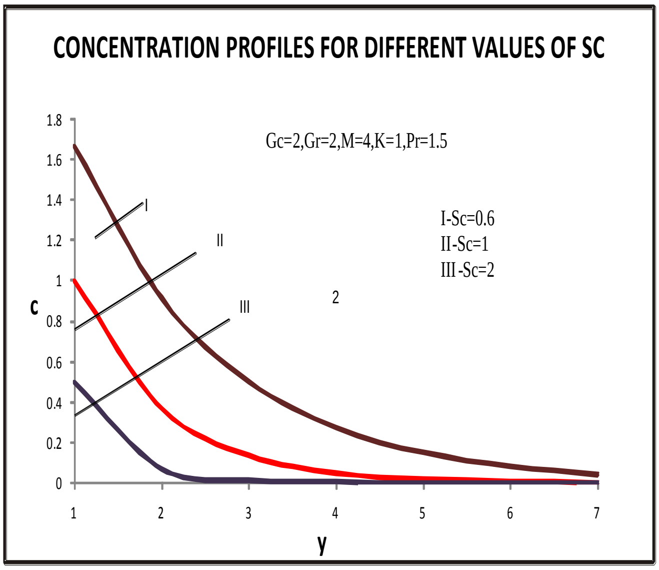



FIG.-4

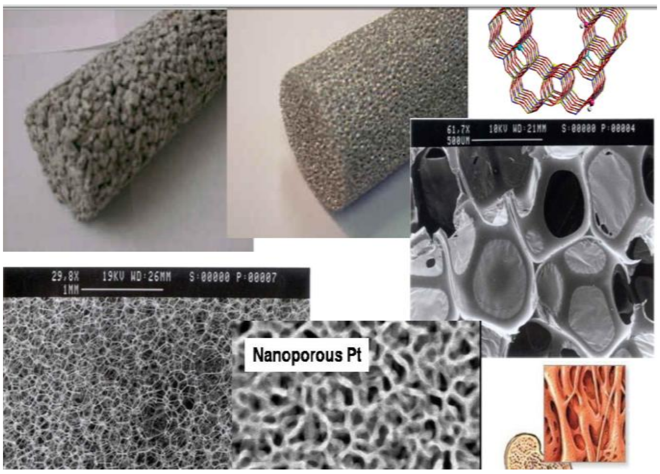



**FIGURE-6**

The study of flows through porous media has been of keen interest amongst the engineers and the mathematicians due to its importance and wide applications in the field of petroleum technology, soil mechanics, ground water hydrology, seepage of water in river beds, purification and filtration processes, oil engineering and bio – mechanics etc.

## VII. MACROSCOPIC PORE STRUCTURE PARAMETERS:

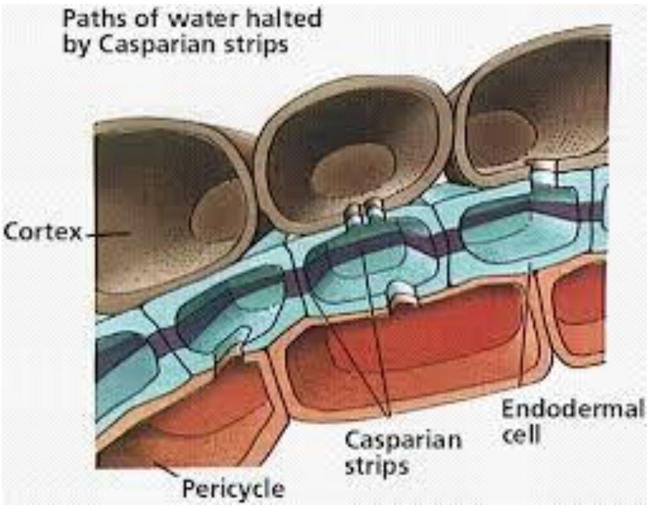
Practically all macroscopic properties of porous media are influenced, to a greater or lesser degree, by the pore structure. Macroscopic pore structure parameters are (in most cases) completely determined by the pore structure of the medium and do not depend on any other property. The most important macroscopic pore structure parameters are the 'porosity', the 'permeability', the 'specific surface area', the 'formation resistivity factor' and the reduced 'breakthrough capillary pressure'.

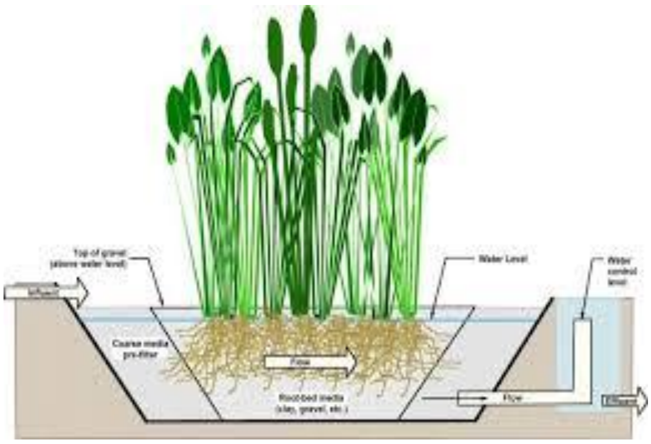
## VIII. POROSITY:

'Porosity' (also called 'void age') $\phi$ is the fraction of the bulk volume of the porous sample that is occupied by pore or void space. Depending on the type of the porous medium, the porosity may vary from near zero to almost unity. For example, certain types of volcanic rocks have very low porosities, whereas fibrous filters and insulators are highly porous substances.

## IX. APPLICATION:

In Capillary tubes water flows in vertical direction(one direction) through xylem and phloem, and this water goes to stomata for photosynthesis. This way plants grows by the transformation of heat and mass transfer. In vertical direction if we apply Magnetic field externally than the rate of mass and heat transfer will be changed due to this rate of photosynthesis also be changed and thus the growth rate of plant will be affected. According to our results if it requires to grow the plant fast for Industrial purpose, it must be kept in low magnetic area but for low growth rate an external magnetic field must be applied.

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