Studies of MHD Flow on stretching surface through Porous Medium with Heat Transfer

***Satish Kumar**
(Asst.Prof. GDC, Lalitpur)

**** Bhagawat Swarup Yadav**
(Asso. Prof. Agra College, Agra)

***** Keshav Dev**
(Asso. Prof. GDC, Lalitpur)

****** Sanjeev sakiya**
(Asst.Prof. GDC, Lalitpur)

Email: Sat2342@yahoo.com

Abstract:

This Paper analyzed the effects on magnetic field of an incompressible viscous fluid past a porous plate i.e. the fluid is electrically conducting, the effects of the porosity of the medium, the surface stretching velocity, The heat generation coefficient on both the flow and heat transfer are presented. A numerical solution for the governing nonlinear momentum and energy equations is obtained.

Key words: MHD Flow, Porous medium, Heat Transfer, Finite Differences.

1. Introduction

The problem of MHD 2-D laminar flow through a porous medium has very important in recent year particularly in the field of agricultural engineering to study the underground water resources, seepage of water river beds, in chemical engineering for filtration purification process; in petroleum technology to study the movement of natural gas, oil and water through the oil reservoirs.

The purpose of the present paper is to study the hydro magnetic effects of electrically conducting two-dimensional flow of viscous incompressible fluid through a porous medium, which is bounded by an infinite porous plate. Ahmadi (1971), Gupta (1977) discussed Heat and mass transfer on stretching sheet with suction or blowing. Raptis (1983) discussed about the unsteady flow through a porous medium bounded by an infinite porous plate subjected to a constant suction variable temperature. Dutta (1985) discussed the Temperature field in the flow over stretching surface with uniform heat flux. Massoudi et all (1992) used a perturbation technique to solve the stagnation point flow and heat transfer of a non-Newtonian fluid of second grade. Ariel (1994) gives the Hiemenz Flow in Hydromantic. Young (2000) unsteady MHD convective heat transfer as a semi vertical porous moving plate with variable suction. Singh et al (2001) analyzed the effect of periodic variation of suction velocity. Attia (2003) discussed Hydro magnetic stagnation point flow with heat transfer over a permeable surface. Kumar (2004) discussed the hall current effect on MHD convection flow through a porous media with semi-infinite vertical plate with mass transfer. Mohammad **et** al (2005) analyzed the effect of hall current and heat transfer on flow due to a pull of eccentric rotating. **Attia** (2006) discussed the unsteady MHD couette and heat transfer of dusty fluid variable physical properties. Haken (2007) discussed the tuncay yilm two-dimensional natural convection in a porous triangular enclosure with a square body. Ahamad (2007) effects of variable viscosity on non-Darcy MHD free convection along a non-isothermal vertical surface in a thermally stratified porous medium. Hayat et al (2008) discussed the heat transfer analysis on the MHD flow of a second grad fluid in channel with porous medium.

2. Mathematical Formulation:

We consider the 2-D MHD flow in a porous medium of viscous incompressible fluid near a stagnation point at a. the flow being in a region y>0 and we consider two equal and opposing forces along the x-axis and keeping the origin fixed. The potential flow that arrives from the y-axis. The viscous flow must adhere to the wall, where as the potential slides along it. (u^*, v^*) are the components for the potential flow of velocity at the point (x^*, y^*) for the viscous flow, where as (U,V) are the components for the potential flow.
The velocity distribution in the frictionless MHD flow is given by

$$U(x^*) = dx^*,\ V(x^*) = -dy^* \qquad \ldots (1)$$

Where the constant $d > 0$ is the distance of the velocity from the stretching surface y = 0
The continuity and momentum equation for 2-D steady-state problems is given by

$$\frac{\partial u^*}{\partial x^*} + \frac{\partial v^*}{\partial y^*} = 0 \qquad \ldots(2)$$

$$\rho\left(u^*\frac{\partial u^*}{\partial x^*} + v^*\frac{\partial u^*}{\partial y^*}\right) = U\frac{dU}{dx^*} + \left(\mu\frac{\partial^2 u^*}{\partial y^{*2}}\right) + \frac{\mu}{K}U(x^*) - \left(\frac{\mu}{K} + \frac{\sigma\beta_0^2}{\rho}\right)u^* \qquad \ldots(3)$$

Where ρ is the density of fluid, β_0 is the magnetic field component along y^*. K is the Darcy permeability and σ is the electric conductivity of porous medium.
The boundary condition of above flow problem is given by

$$\begin{aligned} &y^* = 0:\ u^* = cx^*,\ v^* = 0 \\ &y^* \to \infty:\ u^* \to dx^* \end{aligned} \qquad \ldots (4)$$

Where c is positive constant. The continuity and momentum equations admit a similarity solution

$$u^*(x^*, y^*) = cx^* f'(\eta),\quad v = -\sqrt{c\upsilon}\, f(\eta),\ \eta = \sqrt{\frac{c}{\eta}}\, y^* \qquad \ldots(5)$$

Where υ = μ/ρ is the kinematics viscosity of fluid and prime denotes the differentiation with respect to η. Using equation (4) the continuity equation (2) is satisfied and using (4) and (5) the equation (3) reduce in the form

$$f'^2 - f''' - ff'' - \frac{C^2}{\rho} - \varepsilon(C-1) + \frac{MU}{cd} f' = 0 \qquad ...(6)$$

$\varepsilon = \dfrac{\nu}{cK}$ *is the porosity of medium*

$C = \dfrac{a}{c}$ *is the stretching parameter*

$M = \dfrac{\beta_0}{V}\sqrt{\dfrac{\sigma}{\mu}}$ *is the Hartmann number*

d = *wave length*

And the boundary of this situation

$$f(0)=0, \quad f'(0)=1, \quad f'(\infty) = C \qquad ...(7)$$

The energy equation of such problem is given by

$$\rho Cp\left(u^*\frac{\partial T^*}{\partial x^*} + U\frac{\partial T^*}{\partial y^*}\right) = K\frac{\partial^2 T^*}{\partial y^{*2}} + Q(T^* - T^*_\infty) \qquad ...(8)$$

Where Cp is the heat capacity at pressure of fluid, K is thermal conductivity of fluid, T_∞ is the constant temperature far away from the stretching surface, Q is the volumetric rate of heat generation, T is the temperature profile, T_w and T_∞ are the wall and stream temperature respectively are constant.

The thermal boundary conditions are

$$\left.\begin{aligned} & y^*=0; \quad T^*=T^*_w; \quad \theta^* = \frac{T^*-T^*_\infty}{T^*_w - T^*_\infty} \\ & y^* \to \infty; \quad T^* = T^*_\infty \end{aligned}\right\} \qquad ...(9)$$

Applying the boundary (9) the energy equation (8) reduced in the form

$$\theta'' + \Pr f\theta' + B\Pr\theta = 0 \qquad ...(10)$$

where

$\Pr = \dfrac{\mu Cp}{K}$ *prandtl number*

$B = \dfrac{Q}{c\rho Cp}$ *is the dimensional heat generation*

3. Results and Discussion:

Figure (1) and (2) shows the velocity profile for the varies values of C and M. these figure shows that increasing the parameter C then increasing both f and $f^{/}$. For C<1, increasing M then increasing f and $f^{/}$. For C>1, increasing M then decreasing both f and $f^{/}$. These figures show the effect of C on both f and $f^{/}$. More ever, increasing C decreasing the boundary layer thickness. Figure (3) represent the temperature θ for varies value of c and M and for Pr = 0.6 and B =0.1. It is clear that increasing C decreasing θ. This figure indicates that the thermal boundary layer thickness decreasing when increasing and increasing M decreasing θ for all C.

In this problem the result indicate that increasing the stretching velocity increasing the velocity components but decreasing the velocity boundary layer thickness. But increasing stretching velocity decreasing the temperature as well as the thermal boundary layer thickness. The effect of the stretching parameter on the velocity and temperature is apparent for the smaller values of porosity parameters.

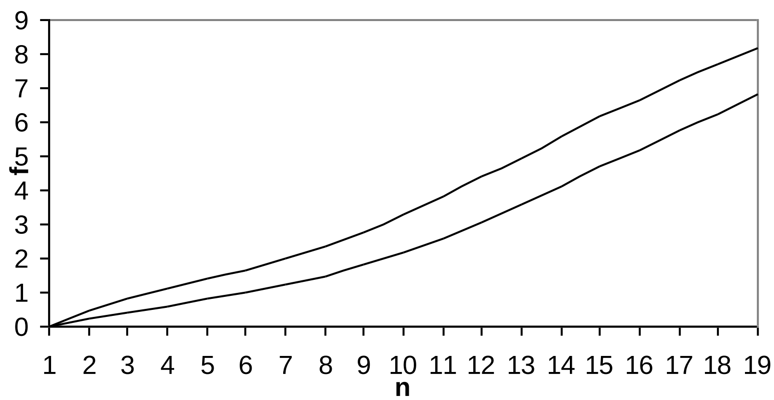

Figure 1. Effect of the parameters C and M on the profile of *f*

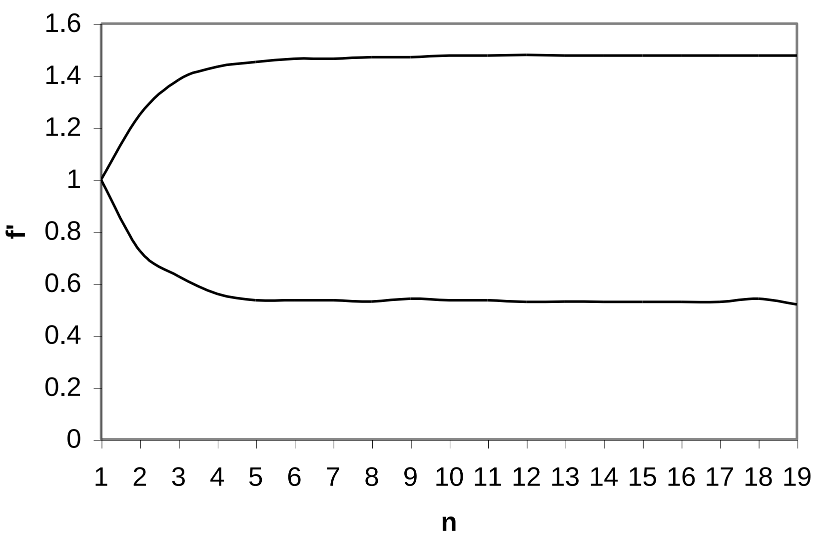

Figure 2. Effect of the parameters C and M on the profile of *f'*

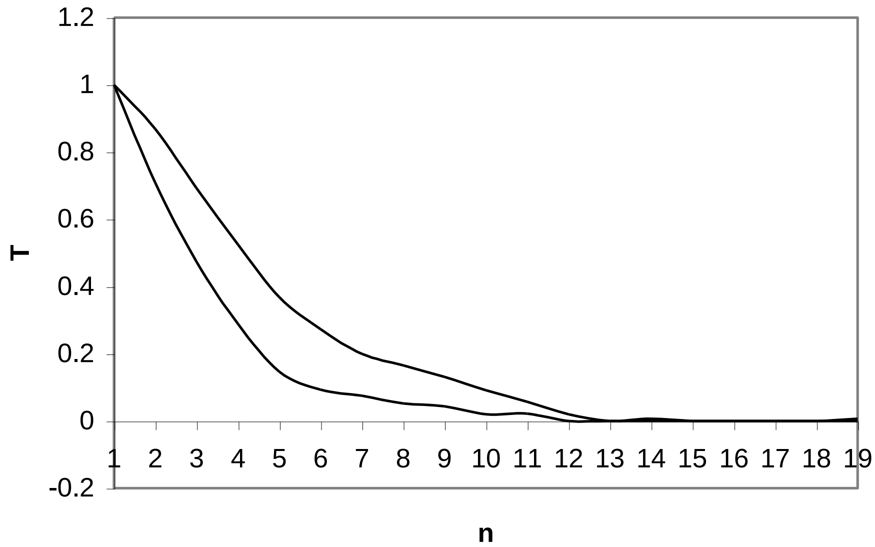

Fig.-3 temperature distribution

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