Finite Difference Solution on Unsteady MHD Free Convective Heat and Mass Transfer Flow along a Vertical Porous Plate with internal Heat Source and Suction

Bandham Saidulu

Assistant professor, Department of mathematics.
Princeton Degree & PG College, Ramanthapur, Hyderabad-500013, T.S (INDIA)

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Abstract - *This paper presents with the effects on unsteady MHD free convective heat and mass transfer flow along a vertical porous plate with heat source and suction in the presence of transverse magnetic field. The governing equations velocity, temperature and concentration are changed into ordinary differential equations by using flow parameter solved by finite difference technique. The effects of different flow parameters on velocity , temperature , and concentration profiles are demonstrated graphically and discussed.*

Key Words: **magnetic field, Free convection, Porous plate, Mass transfer, MHD, heat Source, Suction.**

1. INTRODUCTION

The study of fluid flow along a vertically porous plate in the presence of the magnetic field and internal heat generation which is used in different branches of science and technology like geophysical science. R.C Choudary and Arpita Jain [1] investigated an exact solution of magnetohydrodynamic convection flow past an accelerated surface embedded in porous medium. S.Siviah et.al [2] have studied finite element analysis of chemical reaction and radiation effects on isothermal vertical oscillating plate with variable mass diffusion. P.R Sharmal et.al [3] have investigated unsteady MHD forced convection flow and mass transfer along a vertical stretching sheet with heat source/ sink and variable fluid properties. Israel – Cookey et al. [4] to study the more general problem which includes thermal radiation, heat source, thermal diffusion and diffusion thermo unsteady MHD free convective flow past an infinite vertical plate. The effects of Hall currents, Soret and Dufour on an unsteady magnetohydrodynamic flow and heat transfer along a porous flat plate with mass transfer studied by Anand Rao and Srinivasa Raju [5]. P.Srikanth Rao and D.Mahendar [6] investigated Soret effect on unsteady MHD free convection flow past a semi-infinite vertical permeable moving plate. D.Chennakesavaiah and P V Satyanarayana[7]. Rao and Shivaiah [8] studied chemical reaction effects on unsteady MHD flow past semi- infinite vertical porous plate viscous dissipation. Anand Rao and S. Shivaiah [9] analyzed chemical reaction effects on an unsteady MHD free convective flow past in infinite vertical plate with constant suction and heat source.

Aim of this paper is looked into the flow of electricity conducting fluid along a porous isothermal non conducting perpendicular plate in the presence of transverse magnetic field and internal heat generation and suction.

2. FORMULATION OF THE PROBLEM

Template sample paragraph . By considering laminar two-dimensional free flow of incompressible viscous electrical conducting fluid through a vertical non conducting porous plate. By taking the x −axis along the plate and y −axis is perpendicular to the plate. In y −direction, magnetic field of intensity B_o is applied. Let u and v are the velocity components along x −axis and y-axis.

$\frac{\partial v}{\partial y} = 0 \Rightarrow$ v is independent of y

$$v = v(t) \qquad \dots (1)$$

$$\frac{\partial u}{\partial v} + v\frac{\partial u}{\partial y} = v\frac{\partial^2 u}{\partial y^2} + g\beta(T - T_\infty) + g\beta_c(C - C_\infty) - \sigma\frac{B_0^2}{\rho}u \qquad \dots (2)$$

$$\rho C_P\left(\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y}\right) = K\frac{\partial^2 T}{\partial y^2} + Q \qquad \dots (3)$$

$$\frac{\partial C}{\partial t} + v\frac{\partial C}{\partial y} = D\frac{\partial^2 C}{\partial y^2} \qquad \dots (4)$$

The boundary conditions are

$$u=0, v=v(t), T=T_0, C=C_0 \ at\ y\to 0,$$
$$u\to 0, T\to T_\infty, C\to C_\infty \ as\ y\to\infty, t\to 0. \qquad \dots (5)$$

3. METHOD OF SOLUTION

Setting the time dependent similarity having the scale as

$$h=\{=h(t)\}=2\sqrt{vt} \qquad \dots (6)$$

particularly used for unsteady boundary layer problems. In terms of $h\,(t)$, a appropriate solution of (1) is given by $v = v(t) = -V\,\dfrac{v}{h(t)}$ ... (7)

where V is suction parameter

On introducing the following dimensionless variable for a similarity solution

$$\eta = \frac{y}{h}, u = Uf, \theta = \frac{(T - T_\infty)}{(T_0 - T_\infty)}, \phi = \frac{(C - C_\infty)}{(C_0 - C_\infty)} \quad \text{... (8)}$$

Substituting the above similarities into the equations (2) to (4), we get the following equations

$$f'' + (2\eta + V)f' + Gr\,\Theta + GC\emptyset - Mf = 0 \quad \text{... (9)}$$

$$\Theta'' + (2\eta + V)Pr\,\Theta' + S\Theta = 0 \quad \text{... (10)}$$

$$\emptyset'' + (2\eta + V)S_c\emptyset' = 0 \quad \text{... (11)}$$

The boundary conditions are transformed to

$$f(0) = 0, \theta(0) = 1, \phi(0) = 1, \quad at\ \eta \to 0$$
$$f(\infty) = 0, \theta(\infty) = 0, \phi(\infty) = 0, \quad as\ \eta \to \infty \quad \text{... (12)}$$

The governing equations (9) to (11) are second ordered linear differential equations and solved under the boundary conditions (12) using finite difference technique.

Skin –friction coefficient at the plate is given by

$$C_f = \frac{2\nu f'(0)}{Uh} \quad \text{... (13)}$$

The rate of heat transfer in terms of Nusselt number is given by

$$N_u = \frac{2q\sqrt{Vt}}{K(T_0 - T_\infty)} = -q\theta'(0) \quad \text{... (14)}$$

Sherwood number is given by

$$Sh = \frac{Jv}{(C_0 - C_\infty)Dv} = -f'(0) \quad \text{... (15)}$$

Where q is heat flux per unit area, J mass transfer coefficient.

The system of transformed ordinary differential equations (9)-(11) subject to the boundary conditions (12) is solved numerically by finite difference method by observing the results with the help of the following graphs. It is observed that the figure (1) and figure (3) found that velocity profile decreases with the increase of magnetic parameter increases and Prandtl number. Figure (2), observed the velocity increases as the heat generation parameter increases. Figure (4), shows that velocity distribution decreases as the suction parameter increases. From the figure (5), we observe that the temperature field increases as heat generation parameter s increases. Figure (6), demonstrates that the temperature profile decreases with increasing Prandtl number.

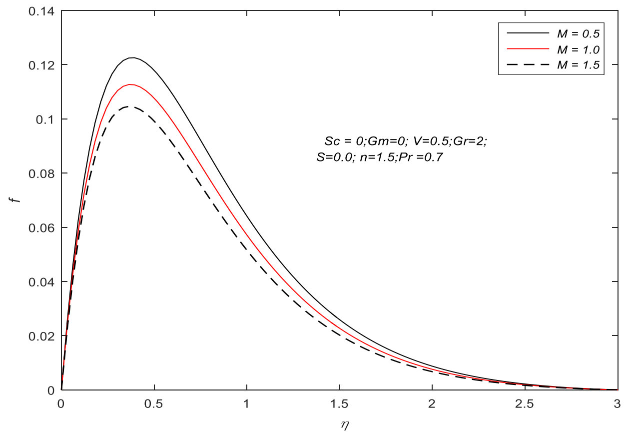

Fig.1. Velocity profiles M versus η

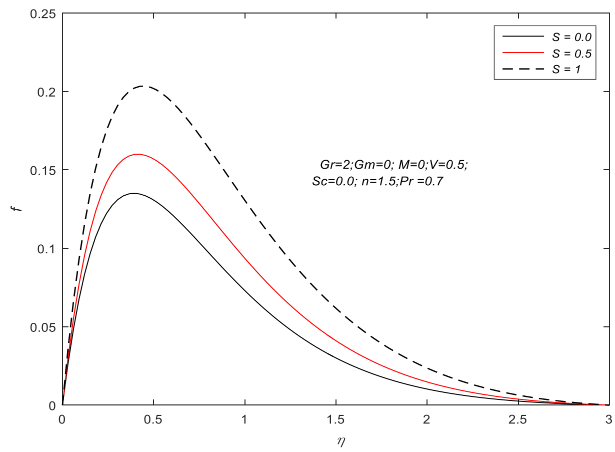

Fig.2. Velocity profiles S versus η

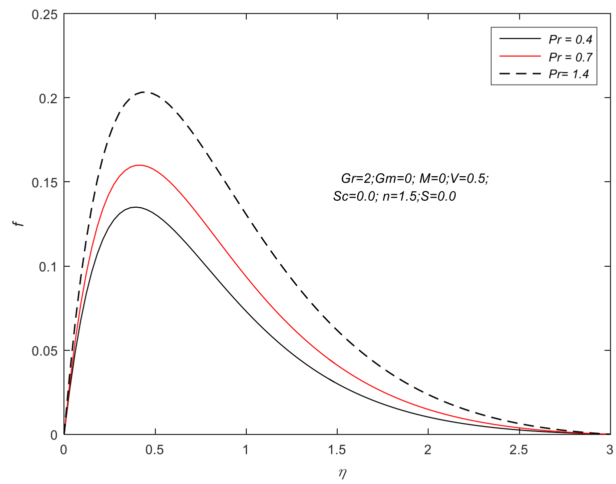

Fig.3. Velocity profiles Pr versus η

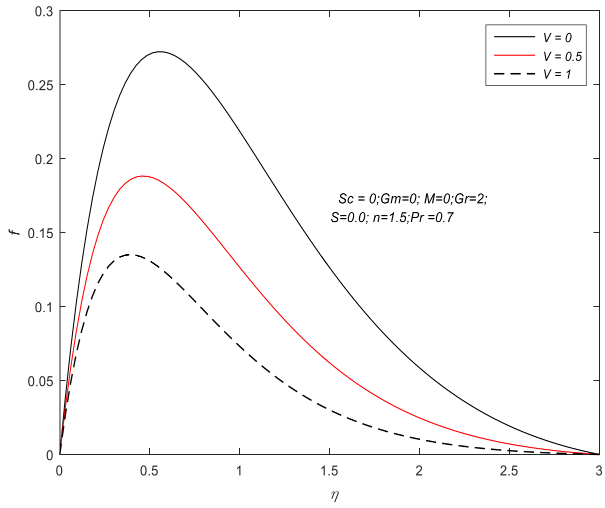

Fig.4. Velocity profiles Vversus η

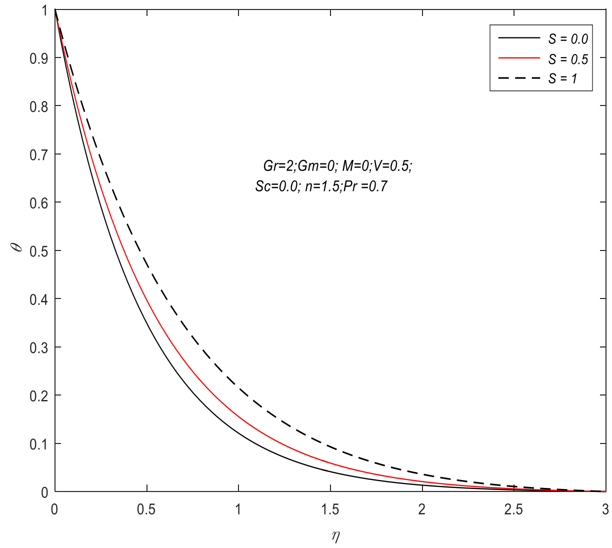

Fig. 5: Temperature profiles versus when η

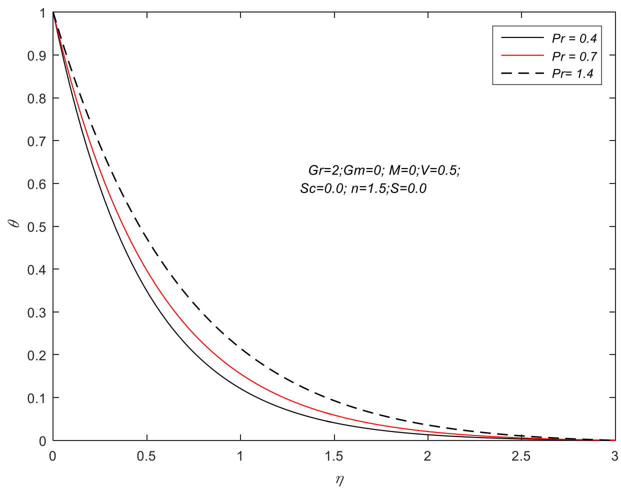

Fig. 6. Temperature profiles versus η

REFERENCES

[1] R.C choudary.,Arpita Jain "An exact solution of magnetohydrodynamic convection flow past an accelerated surface embedded in porous medium", International Journal of Heat and Mass Transfer, 53, pp.1609–1611, 2010.

[2] S. Sivaiah,. G. Murali., and M. C. K. Reddy "finite element analysis of chemical reaction and radiation effects on isothermal vertical oscillating plate with variable mass diffusion", ISRN Mathematical Physics Volume 2012, pp. 1-14.

[3] P.R Sharma , Manisha Sharna and R.S Yadav, International Research Journal of Engineering and Technology (IRJET), 02 (03), pp-1321-1332,2015.

[4] Israel – Cookey C., Ogulu, A. and Omubo – Pepple, V. B. Influence of viscous dissipation and radiation on unsteady MHD free convection flow past an infinite heated vertical plate in a porous medium with time – dependent suction, International Journal of Heat and Mass Transfer, Vol. 46 pp. 2305 – 2311,2003.

[5] Anand Rao, J. and Srinivasa Raju, The effects of Hall currents, Soret and Dufour on MHD flow and heat transfer along a porous flat plate with mass transfer, Journal of Energy, Heat and Mass Transfer, Vol. 33, pp. 351 – 372, 2011.

[6] P.Srikanth Rao and D.Mahendar "Soret effect on unsteady MHD free convection flow past a semi-infinite vertical permeable moving plate", International of Mathematical Archive, 5(8), pp.235-245, 2014.

[7] D. Chenna Kesavaiah and P V Satyanarayan "Radiation absorption and dufour effects to mhd flow in vertical surface",Global journal of engineering ,design & technology, 3(2) ,51-57, 2014.

[8] Rao and Shivaiah "Studied chemical reaction effects on unsteady MHD flow past semi- infinite vertical porous plate viscous dissipation", Appl.Math.Mech-Engl.Ed., 34(8), pp. 1065-1078, 2011.

[9] J. Anand Rao and S. Shivaiah, chemical reaction effects on an unsteady MHD free convective flow past in infinite vertical plate with constant suction and heat source, International Journal of Applied Mathematics and Mechanics, 7(8) , pp. 98–118, 2011.