Diffusion-Thermo and Thermal-Diffusion Effect on Flat Surface in Presence of Magnetohydrodynamic

P. Geetha, M. Dhavamani

***Abstract---** Investigation is made with magnetohydrodynamics on Diffusion-Thermo and Thermal-Diffusion effect on flat surface. The governing partial differential equations are transformed into non-linear differential equations. Runge-Kutta Gill method (RK method) with shooting techniques is applied. Graphical representation of magnetic field parameter (M), Eckert number (Ec), Prandtl number (Pr), Lewis number (Le), Dufour (D_f) and Soret (Sr) parameters are given and discuessed.*

***Key Words:** Magnetohydrodynamics, heat and mass transfer, viscous dissipation, Thermal-Diffusion effect and Diffusion-Thermo effect.*

INTRODUCTION

Magnetohydrodynamics is the study of the magnetic properties and behavior of electrically conducting fluids that is applied in various industries. Krishna et.al [1] investigated radiation with the presence of generation of heat. Vidyasagar et.al [2] discussed MHD flow on permeable stretching surface. Ramana et.al [4] studied thermal diffusion effect on unsteady flow. The investigation of radiation on boundary layer have been done by Krishna et.al [5].

This paper analyze the Diffusion-Thermo and Thermal-Diffusion effect on flat surface in presence of Magnetohydrodynamic

PROCEDURE

The diffusion-thermo and thermal-diffusion effect in presence of magnetohydrodynamics of a viscous incompressible fluid is considered. The "x-axis" represent the flow of fluid and "y-axis" perpendicular to plate. The plate is with temperature T_w that is greater when compared with the free stream T_∞. The plate is with constant concentration C_w that is greater than T_∞ of the surrounding fluid. Assumption is made in such a way that there is no applied voltage, hence there is no electric field. Also we assumed that viscosity (μ) vary as inverse function of temperature and Boussinesq approximations,

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

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} - \frac{\sigma_e B_0^2 u}{\rho} \quad \ldots(2)$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \frac{\nu}{c_p}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{\sigma_e B_0^2 u^2}{\rho c_p} + \frac{D_m k_T}{c_s c_p}\left(\frac{\partial^2 c}{\partial y^2}\right) \quad \ldots(3)$$

$$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D_m\frac{\partial^2 C}{\partial y^2} + \frac{D_m k_T}{T_m}\left(\frac{\partial^2 T}{\partial y^2}\right) \quad \ldots(4)$$

The conditions pertains to:

$$y = 0;\ \ u = U_w,\ \ v = 0,\ T = T_w,\ \ \ C = C_w$$
$$y \to \infty;\ u \to U_\infty,\ \ T \to T_\infty,\ \ \ C \to C_\infty \quad \ldots(5)$$

METHODOLOGY

ψ(x,y) is defined as

$$u = \frac{\partial \psi}{\partial y},\ \ v = -\frac{\partial \psi}{\partial x} \quad \ldots(6)$$

So that (1) gets satisfied.

The governing system of equations (2), (3) and (4) are transformed using

$$\psi(x,y) = \sqrt{2\nu U x}\ f(\eta)$$
$$\theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty} \quad \ldots(7)$$
$$\varphi = \frac{C - C_\infty}{C_w - C_\infty}$$

where $\eta = y\sqrt{\frac{U}{2\nu x}}$ ...(8)

and $U = U_w + U_\infty$ is composite reference velocity.

The equations (2), (3) and (4) are reduced :

$$f''' + ff'' - Mf = 0 \quad \ldots(9)$$

$$\theta'' + \Pr f\theta' + \Pr Ecf''^2 + M\Pr Ecf'^2 + D_f\phi'' = 0 \quad \ldots(10)$$

$$\frac{1}{Le}\phi'' + f\phi' + S_r\theta'' = 0 \quad \ldots(11)$$

The conditions pertains to :

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$$\eta = 0; \; f = 0, \;\; f^{'} = 1 - r, \; \theta = 1, \; \phi = 1$$
$$\eta \to \infty; \; f^{'} \to r, \; \theta \to 0, \; \phi \to 0 \qquad \ldots(12)$$

where $r = \frac{U_\infty}{U} = \frac{U_\infty}{U_w + U_\infty}$ is a moving parameter (0 $\le r \le 1$) S_r – Thermal-Diffusion number, D_f – Diffusion-Thermo number,θ - Dimensionless temperature, Ψ - Stream function, ϕ - Dimensionless concentration, η - Similarity variable, f – Dimensionless stream function, Magnetic number $M = \frac{2\sigma_e x B_0^2}{\rho U}$, Prandtl number $\Pr = \frac{\nu}{\alpha}$ and Eckert number $Ec = \frac{U^2}{c_p (T_w - T_\infty)}$.

Using similarity variables, we obtain in non-dimensional form as

$$c_f = \sqrt{\frac{2}{\mathrm{Re}}} f^{''}(0)$$
$$Nu = -\sqrt{\frac{\mathrm{Re}}{2}} \theta^{'}(0) \qquad \ldots(13)$$

NUMERICAL SOLUTION

The equations (9), (10), and (11) with (12) were solved using RKl method along shooting technique, a guessing of $f^{''}(0), \theta^{'}(0)$ and $\phi^{'}(0)$ are made.

The order of convergence is accurate by choosing the step size as $\Delta\eta$ = 0.001. The computer language FOTRAN is used for computation purpose. The numerical values of c_f, Nu and Sh are shown in the table.

RESULTS AND DISCUSSION

Fig.1 it is noted that as M rises the fluid velocity falls down. Fig. 2 shows decrease in velocity results with rise in the Diffusion-Thermo (Df) and Thermal-Diffusion (Sr). It is noted that from Fig.3 the rise in Prandtl number (Pr) reduce the fluid velocity. Fig.4 describes rise in temperature results in rise in magnetic field parameter. The temperature for various values of Ec and Pr are presented through Fig.5 & Fig.7. It describes the rise in Pr decrease in thermal boundary layer. Fig. 6 indicates, boundary layer shoots up with an rise in the Diffusion-Thermo number and Thermal-Diffusion number. Finally, it is observed from Fig.8 as the value of M rises the concentration reduces. From Fig.9 concentration reduces with an rise in the Diffusion-Thermo number and Thermal-Diffusion number.

CONCLUSION

- The graph of velocity reduce but the graphs of concentration shoot up by increasing magnetic field parameter.
- Temperature graph pertaining to Diffusion-Thermo rise and Thermal-Diffusion fall with the shoot up value of velocity and fall down value of concentration.
- The Nusselt number falls as the Diffusion-thermo number rise.

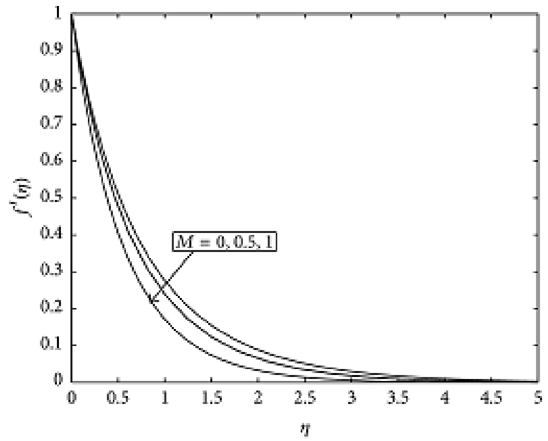

Fig. 1 Velocity graph of M

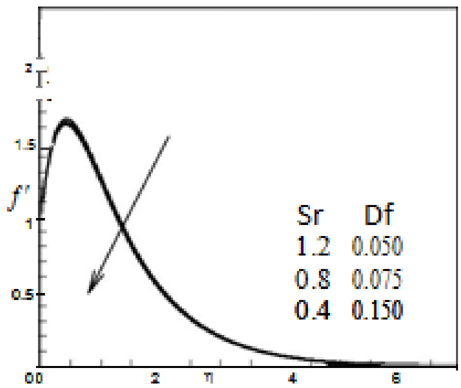

Fig.2 Velocity graph of Sr & Df

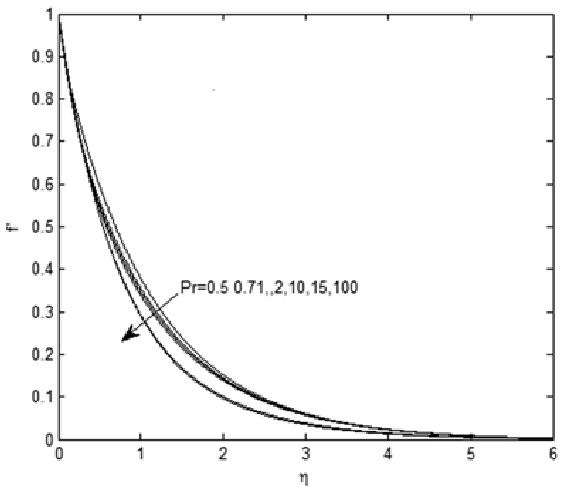

Fig. 3 Velocity graph of Pr

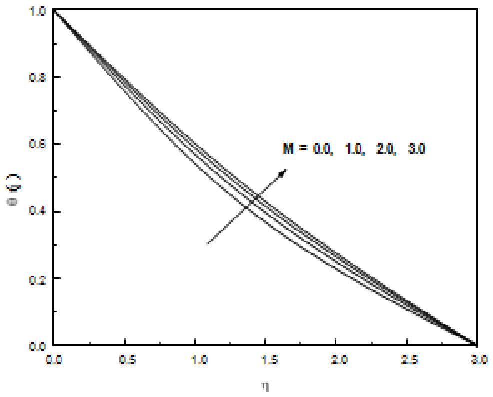

Fig. 4 Temperature graph of M

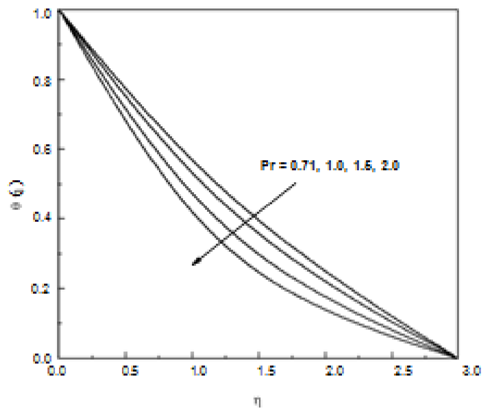

Fig.5 Temperature graph of Pr

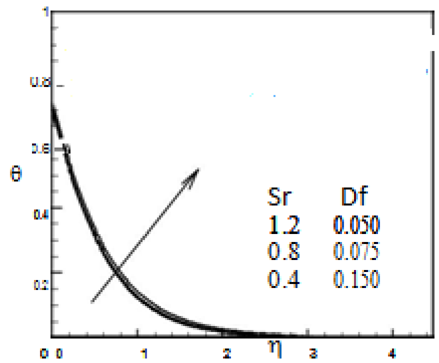

Fig.6 Temperature graph of Sr & Df

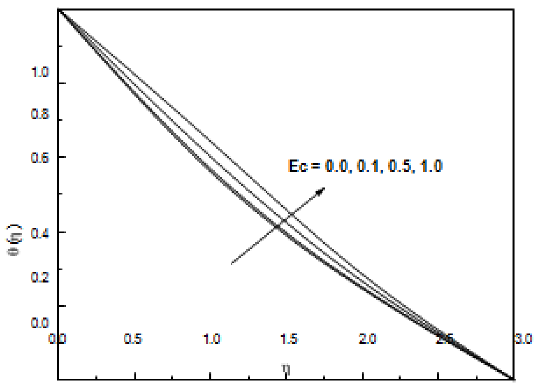

Fig. 7 Temperature graph of Ec

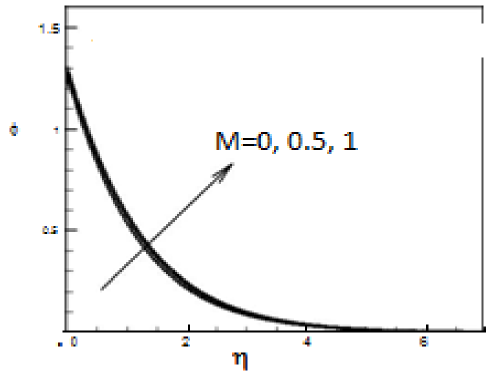

Fig. 8 Concentration graph of M

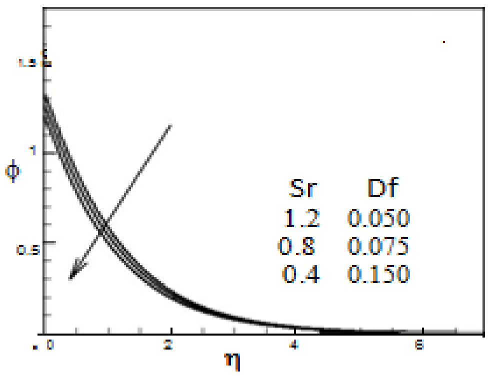

Fig.9 Concentration graph of Sr & Df

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