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HYDROMAGNETIC DOUBLE DIFFUSIVE CONVECTION–RADIATION INTERACTION ON STEADY FLOW OF A VISCOUS DISSIPATIVE, CHEMICALLY REACTING FLUID IN A NON-UNIFORMLY HEATED VERTICAL CHANNEL WITH SORET EFFECT

[1]V. Sugunamma and [1]M. Snehalatha*

[1]*Department of Mathematics, S. V. University, Tirupathi, (A.P.), India.*

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ABSTRACT

We discuss the effect of radiation on mixed convective heat and mass transfer flow of a viscous, electrically conducting, incompressible in a vertical channel bounded by flat walls. A non-uniform temperature is imposed on the walls and the concentration on these walls is taken to be constant. The viscous dissipation is taken in to account in the energy equation. Assuming the slope of the boundary temperature to be small, we solve the governing momentum, energy and diffusion equations by a perturbation technique. The velocity, the temperature, the concentration, the rate of heat and mass transfer have been analysed for different variations of the governing parameters.

Keywords: *MHD, Non-uniform temperature, radiation, dissipation, Chemical reaction.*

1. INTRODUCTION

This problem of combined buoyancy driven thermal and mass diffusion has been studied in parallel plate geometries by a few authors in the recent times, notably Gebhart [21], Lai[33,33a], Chen and Mout Sogloy [14], Poulikakos [44], Trevisan and Bejan [57], Mehta and Nanda Kumar[40] and Angiras *et al* [1].

In the above mentioned investigations the bounding walls are maintained at constant temperature. However, there are a few physical situations which warrant the boundary temperature to be maintained non-uniform. It is evident that in forced or free convection flow in a channel (pipe) a secondary flow can be created either by corrugating the boundaries or by maintaining non-uniform wall temperature Such a secondary flow may be of interest in a few technological process. For example in drawing optical glass fibres of extremely low loss and wide bandwidth, the process of modified chemical vapour deposition (MCVD) [32, 50] has been suggested in recent times. Performs from which these fibres are drawn are made by passing a gaseous mixture into a fused–silica tube which is heated locally by an oxy-hydrogen flame. Particulates of Sio_2- Geo_2 composition are formed from the mixture and collect on the interior of the tube. Subsequently these are fined to form a victreous deposit as the flame traversed along the tube. The deposition is carried out in the radial direction as the flame traversed along the tube. The deposition is carried out in the radial direction through the secondary flow created due to non-uniform. Ravindranath *et al* [58] have studied the combined effect of convective heat and mass transfer on hydromagnetic electrically conducting viscous incompressible fluid through a porous medium in a vertical channel bounded by flat walls which are maintained at non-uniform temperatures.

All the above mentioned studies are based on the hypothesis that the effect of dissipation is neglected. This is possible in case of ordinary fluid flow like air and water under gravitational force. But this effect is expected to be relevant for fluids with high values of the dynamic viscous flows. Moreover Gehart[22], Gebhart and Mollen dorf[23] have shown that that viscous dissipation heat in the natural convective flow is important when the flow field is of extreme size or at extremely low temperature or in high gravitational filed. On the other hand Barletta [3] has pointed out that relevant effect of viscous dissipation on the temperature profiles and on the Nusselt numbers may occur in the fully developed forced convection in tubes. In view of this several authors notably, Soudalgekar and Pop[53] Raptis etc al [48], Ramana Murthy and Soundelgekar *et al* [51], Barletta (3,4), Sreevani[55]. El-hakeing [18], Bulent Yesilata [10]. Rossidi schi[48a] and Israel *et al* [30] have studied the effect of viscous dissipation on the convective flows past on infinite vertical plates and through vertical channels and Ducts. The effect of viscous dissipation on natural convection has been studied for some different cases including the natural convection from horizontal cylinder. The natural convection from horizontal cylinder embedded in a porous media has been studied by Fand and Brucker [19]. They reported that the viscous dissipation may not be neglected in all cases of natural convection from horizontal cylinders and further, that the inclusion of a viscous dissipation term in porous medium may lead to more accurate correlation equations.

Corresponding author: [1]M. Snehalatha. E-mail: snehalathakushal24@gmail.com*

The effect of viscous dissipation has been studied by Nakayama and Pop [38] for steady free convection boundary layer over a non-isothermal bodies of arbitrary shape embedded in porous media. They used integral method to show that the viscous dissipation results in lowering the level of the heat transfer rate from the body. Costa [16] has analysed a natural convection in enclosures with viscous dissipation. Recently Jambal et al have discussed the effects of viscous dissipation and fluid axial heat conduction heat transfer for non-Newtonian fluids in ducts with uniform wall temperature. Prasad [44a] has discussed the effect of dissipation on the mixed convective heat and mass transfer flow of a viscous fluid through a porous medium in a vertical channel bounded by flat walls. Vijayabhaskar Reddy [58] has analysed the combined influence of radiation and thermo-diffusion on convective heat And mass transfer flow of a viscous fluid in a vertical channel whose walls are maintained at non-uniform temperatures. Deepthi *et al* [17a] have discussed the effect of chemical reaction on convective heat and mass transfer flow of a viscous fluid in a non-uniformly heated vertical channel with heat generating sources. Recently, Sudhakar *et al* [55a] have investigated the effect of thermo-dioffusion on convective heat and mass transfer flow in a non-uniformly heated vertical channel with chemical reaction and heat sources.

In this paper, we discuss the effect of radiation on mixed convective heat and mass transfer flow of a viscous, electrically conducting, and incompressible fluid through a porous medium in a vertical channel bounded by flat walls. A non-uniform temperature is imposed on the walls and the concentration on these walls is taken to be constant. The viscous dissipation is taken in to account in the energy equation. Assuming the slope of the boundary temperature to be small. We solve the governing momentum, energy and diffusion equations by a perturbation technique. The velocity, the temperature, the concentration, the shear stress and the rate of heat transfer have been analysed for different variations of the governing parameters. The dissipative effects on the flow, heat and mass transfer are clearly brought out.

2. FORMULATION OF THE PROBLEM

We analyse the steady motion of viscous, incompressible fluid through a porous medium in a vertical channel bounded by flat walls which are maintained at a non-uniform wall temperature in the presence of a constant heat source and the concentration on these walls are taken to be constant. The Boussinesq approximation is used so that the density variation will be considered only in the buoyancy force. The viscous, Darcy dissipations and the joule heating are taken into account in the energy equation. Also the kinematic viscosity ν, the thermal conducting k are treated as constants. We choose a rectangular Cartesian system 0(x, y) with x-axis in the vertical direction and y-axis normal to the walls. The walls of the channel are at y = ± L.

The flow is maintained by a constant volume flux for which a characteristic velocity is defined as

$$q = \frac{1}{L}\int_{-L}^{L} u\, d\, y\,. \tag{1}$$

The equations governing the flow, heat and mass transfer in terms of steam function ψ after using Rossel and approximation are

$$\left[\frac{\partial\psi}{\partial x}\frac{\partial(\nabla^2\psi)}{\partial y}-\frac{\partial\psi}{\partial y}\frac{\partial(\nabla^2\psi)}{\partial x}\right]=\nu\left(\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}\right)^2-\beta\, g\frac{\partial T}{\partial y}-\beta^{\bullet}\, g\frac{\partial C}{\partial y}-\left(\frac{\sigma\mu_e^2 H_o^2}{\rho}\right)\frac{\partial^2\psi}{\partial y^2} \tag{2}$$

$$\rho_e C_p\left(-\frac{\partial\psi}{\partial y}\frac{\partial\theta}{\partial x}+\frac{\partial\psi}{\partial x}\frac{\partial\theta}{\partial y}\right)=\lambda\nabla^2\theta+\mu\left(\left(\frac{\partial^2\psi}{\partial y^2}\right)^2+\left(\frac{\partial^2\psi}{\partial x^2}\right)\right)^2+\left(\left(\frac{\mu}{k}\right)\left(\frac{\partial\psi}{\partial x}\right)^2+\left(\frac{\partial\psi}{\partial y}\right)\right)^2+\frac{4}{3N_1}\frac{\partial^2\theta}{\partial y^2} \tag{3}$$

$$\left(-\frac{\partial\psi}{\partial y}\frac{\partial C}{\partial x}+\frac{\partial\psi}{\partial x}\frac{\partial C}{\partial y}\right)=D_1\left(\frac{\partial^2 C}{\partial x^2}+\frac{\partial^2 C}{\partial y^2}\right)+k_{11}\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right)-k_1' C \tag{4}$$

Introducing the non-dimensional variables in (2) - (4) as

$$(x',\ y')=(x,y)/L,\ (u',v')=(u,v)/q, \theta=\frac{T-T_e}{\Delta T_e}, C^{\bullet}=\frac{C-C_1}{C_2-C_1}$$

$$p'=\frac{p_D}{\rho_e q^2},\quad \gamma'=\frac{\gamma}{\Delta T_e} \tag{5}$$

(Under the equilibrium state $\Delta T_e = T_e(L) - T_e(-L) = \left(\frac{QL^2}{\lambda}\right)$

The governing equations in the non-dimensional form (after dropping the dashes) are

$$R\frac{\partial(\psi,\nabla^2\psi)}{\partial(x,y)} = \nabla^4\psi - \frac{G}{R}(\theta_y + NCy) - M^2\frac{\partial^2\psi}{\partial y^2} \tag{6}$$

and the energy and diffusion equations in the non-dimensional form are

$$P_1R\left(-\frac{\partial\psi}{\partial y}\frac{\partial\theta}{\partial x} + \frac{\partial\psi}{\partial x}\frac{\partial\theta}{\partial y}\right) = \nabla^2\theta + \left(\frac{P_1R^2E_c}{G}\right)\left(\frac{\partial^2\psi}{\partial y^2}\right)^2 + \left(\frac{\partial^2\psi}{\partial x^2}\right)^2 + (M^2)\left(\left(\frac{\partial\psi}{\partial x}\right)^2 + \left(\frac{\partial\psi}{\partial y}\right)^2\right) \tag{7}$$

$$RSc\left(-\frac{\partial\psi}{\partial y}\frac{\partial C}{\partial x} + \frac{\partial\psi}{\partial x}\frac{\partial C}{\partial y}\right) = \left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2}\right) + \frac{ScS_o}{N}\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) - k_1C \tag{8}$$

where

$R = \frac{qL}{\nu}$ (Reynolds number), $G = \frac{\beta g\Delta T_e L^3}{\nu^2}$ (Grashof number

$M^2 = \frac{\sigma\mu_e^2 H_o^2 L^2}{\upsilon^2}$ (Hartmann Number), $\mathrm{P} = \frac{\mu C_p}{k_1}$ (Prandtl number),

$E_c = \frac{\beta g L^3}{C_p}$ (Eckert number), $N = \frac{\beta^\bullet \Delta C}{\beta\Delta T}$ (Buoyancy Number)

$Sc = \frac{\nu}{D_1}$ (Schmidt number), $S_0 = \frac{k_{11}\beta^\bullet}{\beta\nu}$ (Soret parameter)

$\gamma = \frac{k_1^{'}L^2}{D_1}$ (Chemical reaction parameter), $N_1 = \frac{\beta_R\lambda}{4\sigma_\bullet T_e^3}$ (Radiation parameter)

$N_2 = \frac{3N_1}{3N_1+4}$, $P_1 = PN_2$, $\alpha_1 = \alpha N_2$

The corresponding boundary conditions are

$$\psi(+1) - \psi(-1) = -1,\ \frac{\partial\psi}{\partial x} = 0,\ \frac{\partial\psi}{\partial y} = 0 \quad at\ y = \pm 1 \tag{9}$$

$$\theta(x,y) = \gamma(\delta x) \qquad on\ \ y = \pm 1 \tag{10}$$

C= 0 on y = -1, C = 1 on y = 1 (11)

$$\frac{\partial\theta}{\partial y} = 0, \frac{\partial C}{\partial y} = 0 \quad at \quad y = 0 \tag{12}$$

The value of ψ on the boundary assumes the constant volumetric flow in consistent with the hyphothesis (1) .Also the wall temperature varies in the axial direction in accordance with the prescribed arbitrary function γ(x) .

3. ANALYSIS OF THE FLOW

The main aim of the analysis is to discuss the perturbations created over a combined free and forced convection flow due to non-uniform slowly varying temperature imposed on the boundaries. We introduce the transformation

$$\bar{x} = \delta\, x$$

With this transformation the equations (6) - (8) reduce to

$$R\delta \frac{\partial(\psi, F^2\psi)}{\partial(x, y)} = F^4\psi - \frac{G}{R}(\theta_y + NC_y) - M^2 \frac{\partial^2\psi}{\partial y^2} \tag{13}$$

and the energy &diffusion equations in the non-dimensional form are

$$P_1 R\delta\left(-\frac{\partial\psi}{\partial y}\frac{\partial\theta}{\partial x} + \frac{\partial\psi}{\partial x}\frac{\partial\theta}{\partial y}\right) = F^2\theta + \left(\frac{P_1R^2E_c}{G}\right)\left(\left(\frac{\partial^2\psi}{\partial y^2}\right)^2 + \delta^2\left(\frac{\partial^2\psi}{\partial x^2}\right)^2\right) + (M^2)\left(\delta^2\left(\frac{\partial\psi}{\partial x}\right)^2 + \left(\frac{\partial\psi}{\partial y}\right)^2\right) \tag{14}$$

$$\delta RSc\left(-\frac{\partial\psi}{\partial y}\frac{\partial C}{\partial x} + \frac{\partial\psi}{\partial x}\frac{\partial C}{\partial y}\right) = F^2C + \frac{ScSo}{N}F^2\theta - \gamma C \tag{15}$$

where $F^2 = \delta^2\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ for small values of the slope δ,the flow develops slowly with axial gradient of order δ and hence we take

$$\frac{\partial}{\partial \bar{x}} \approx O(1)$$

We follow the perturbation scheme and analyse through first order as a regular perturbation problem at finite values of R, G, P, Sc, So, and D^{-1} Introducing the asymptotic expansions

$$\begin{aligned} y(x, y) &= y_0(x, y) + dy_1(x, y) + d^2y_2(x, y) + \ldots\ldots\ldots \\ q(x, y) &= q_0(x, y) + dq_1(x, y) + d^2q_2(x, y) + \ldots\ldots\ldots \\ C(x, y) &= C_0(x, y) + dC_1(x, y) + d^2C_2(x, y) + \ldots\ldots\ldots\ldots\ldots \end{aligned} \tag{16}$$

On substituting (16) in (13) – (15) and separating the like powers of δ the equations and respective conditions to the zeroth order are

$$\psi_{0,\,yyyyy} - M_1^2\psi_{0,\,yy} = \frac{G}{R}(\theta_{0,y} + NC_{0,y}) \tag{17}$$

$$\theta_{0,yy} = -\frac{P_1R^2Ec}{G}\psi_{0,yy}^2 - \frac{P_1M_1^2Ec}{G}\psi_{0,y}^2 \tag{18}$$

$C_{0,yy} - k\,C_0 = -(ScSo/N)\theta_{0yy}$ (19)

with

$\psi_0(+1) - \Psi(-1) = -1$, $\psi_{0,y} = 0$, $\psi_{0,x} = 0$ at $y = \pm 1$ (3.7a)

$\theta o\,(\pm 1) = \gamma(x)$ at $y = \pm 1$, $C_0(-1) = 0$ $C_0(+1) = 1$ (20)

and to the first order are

$$\psi_{1,\,yyyyy} - M_1^2\psi_{1,\,yy} = -\frac{G}{R}(\theta_{1,y} + NC_{1,y}) + R(\psi_{0,\,y}\,\psi_{0,\,xyy} - \psi_{0,\,x}\,\psi_{0,yyy}) \tag{21}$$

$$\theta_{1,yy} = P_1R(\psi_{0,x}\theta_{0,y} - \psi_{0,y}\theta_{0,x}) - \frac{P_1Ec}{G}(R^2\psi_{1,yy}^2 + M_1^2\psi_{1,y}^2) \tag{22}$$

$C_{1,yy} - (k\,Sc)C_1 = RSc\,(\psi_{0,y}C_{0,x} - \psi_{0,x}C_{0,y}) - (ScSo/N)\theta_{1,yy}$ (23)

$\psi_{1(+1)} - \psi_{1(-1)} = 0$, $\psi_{1,y} = 0$, $\psi_{1,x} = 0$ at $y = \pm 1$ (24)

$\theta_1(\pm 1) = 0$ at $y = \pm 1$, (25)

$C_1(-1) = 0$, $C_1(+1) = 0$ (26)

Assuming Ec<<1 to be small we take the asymptotic expansions as

$$\psi_0(x,y)=\psi_{00}(x,y)+Ec\psi_{01}(x,y)+.....$$

$$\psi_1(x,y)=\psi_{10}(x,y)+Ec\psi_{11}(x,y)+.....$$

$$\theta_0(x,y)=\theta_{00}(x,y)+Ec\theta_{01}(x,y)+.....$$

$$\theta_1(x,y)=\theta_{10}(x,y)+Ec\theta_{11}(x,y)+.....$$

$$C_0(x,y)=C_{00}(x,y)+EcC_{01}(x,y)+.....$$

$$C_1(x,y)=C_{10}(x,y)+EcC_{11}(x,y)+..... \tag{27}$$

Substituting the expansions (27) in equations (17)-(26) and separating the like powers of Ec we get the following equations

$$\theta_{00,yy}=0,\quad \theta_{00}(\pm 1)=\gamma(\bar{x}) \tag{28}$$

$$C_{00,yy}-(kSc)C_{00}=-(ScSo/N)\theta_{00,yy},\quad C_{00}(-1)=0, C_{00}(+1)=1 \tag{29}$$

$$\psi_{00,yyyy}-M_1^2\psi_{00,yy}=-\frac{G}{R}(\theta_{00,y}+NC_{00,y}),$$

$$\psi_{00}(+1)-\psi_{00}(-1)=1, \psi_{00,y}=0, \psi_{00,x}=0 \;\; at \;\; y=\pm 1 \tag{30}$$

$$\theta_{01,yy}=-\frac{P_1M_1^2}{G}\psi^2{}_{00,y}-\frac{P_1R^2}{G}\psi^2{}_{00,yy},\quad \theta_{01}(\pm 1)=0 \tag{31}$$

$$C_{01,yy}-(kSc)C_{01}=-\left(\frac{ScSo}{M}\right)\theta_{01,yy},\;\; C_{01}(\pm 1)=0 \tag{32}$$

$$C_{11,yy}-(kSc)C_{11}=RSc(\psi_{00,y}C_{00,x}-\psi_{1,x}C_{00,y})-\left(\frac{ScSo}{N}\right)\theta_{11,yy},\quad C_{11}(\pm 1)=0 \tag{33}$$

$$\theta_{10,yy}=RP_1(\psi_{00,y}\theta_{00,x}-\psi_{00,x}\theta_{00,y}) \qquad \theta_{10}(\pm 1)=0 \tag{34}$$

$$C_{10,yy}-(kSc)C_{10}=RP_1(\psi_{00,y}C_{00,x}-\psi_{00,x}C_{00,y})-\left(\frac{ScSo}{N}\right)\theta_{10,yy}\quad C_{10}(\pm 1)=0 \tag{35}$$

$$C_{11,yy}-(kSc)C_{11}=RSc(\psi_{00,y}C_{00,x}-\psi_{1,x}C_{00,y})-\left(\frac{ScSo}{N}\right)\theta_{11,yy},\;\; C_{11}(\pm 1)=0 \tag{36}$$

$$\theta_{11,yy}=RP_1(\psi_{00,y}\theta_{1,x}-\psi_{1,x}\theta_{00,y}),\;\; \theta_1(\pm 1)=0 \tag{37}$$

$$C_{11,yy}-(kSc)C_{11}=RSc(\psi_{00,y}C_{00,x}-\psi_{1,x}C_{00,y})-\left(\frac{ScSo}{N}\right)\theta_{11,yy},\quad C_{11}(\pm 1)=0 \tag{38}$$

$$\begin{aligned}&\psi_{11,yyyy}-M_1^2\psi_{1,yy}=-\frac{G}{R}(\theta_{11,y}+NC_{11,y})+R\left(\psi_{00,y}\psi_{11,xyy}-\psi_{00,x}\psi_{01,yyy}+\psi_{01,y}\psi_{00,xyy}-\psi_{01.x}\psi_{00,yyy}\right),\\&\psi_{11}(+1)-\psi_{11}(-1)=0, \psi_{11,y}=0, \psi_{11,x}=0 \;\; at \;\; y=\pm 1\end{aligned} \tag{39}$$

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4. SOLUTION OF THE PROBLEM

Solving the equations (26) - (37) subject to the relevant boundary conditions we obtain

$$\theta_{00} = \gamma(\bar{x})$$

$$C_{00} = 0.5\left(\frac{Ch(\beta_1 y)}{Ch(\beta_1)} + \frac{S\ (\beta_1 y)}{Sh(\beta_1)}\right) + a_3\left(\frac{Ch(\beta_1 y)}{Ch(\beta_1)} - 1\right)$$

$$\psi_{00} = a_9 Ch(M_1 y) + a_{10} Sh(M_1 y) + a_{11} y + \varphi_1(y)$$

$$\varphi_1(y) = -a_6 y^3 - a_7 S\ (\beta_1 y) - a_8 Ch(\beta_1 y)$$

$$\theta_{01} = 0.5 a_{25}(1-y^2) + \frac{a_{26}}{4M_1^2}(Ch(2M_1) - Ch(2M_1 y)) + \frac{a_{27}}{4\beta_1^2}(Ch(2\beta_1) - Ch(2\beta_1 y))$$
$$+ \frac{a_{28}}{\beta_2^2}(Ch(\beta_2 y) - Ch(\beta_2)) - \frac{a_{29}}{\beta_2^2}(Ch(\beta_3 y) - Ch(\beta_3)) + \frac{a_{30}}{30}(1-y^6) + \frac{a_{31}}{12}(y^4 - 1)$$

$$C_{01} = a_{33}\left(Ch(2M_1 y) - Ch(2M_1)\frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right) + a_{34}\left(Ch(2\beta_1 y) - Ch(2\beta_1)\frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right)$$
$$- a_{35}\left(Ch(\beta_2 y) - Ch(\beta_2)\frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right) + a_{36}\left(Ch(\beta_3 y) - Ch(\beta_3)\frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right)$$
$$- a_{37}\left(y^4 - \frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right) - a_{38}\left(y^2 - \frac{Ch(\beta_1 y)}{Ch(\beta_1)}\right)$$

$$\psi_{01} = a_{55} Ch(M_1 y) + a_{56} Sh(M_1 y) + a_{57} y + + a_{58} + \varphi_2(y)$$

$$\varphi_2(y) = a_{47} y^2 + a_{48} y^3 + a_{49} y^5 + a_{50} Sh(2M_1 y) + a_{51} Sh(2\beta_1 y) + a_{52} Sh(\beta_2 y) + a_{53} Sh(\beta_3 y) + a_{54} Sh(\beta_1 y)$$

$$\theta_{10} = a_{71} y^2 + a_{72} y^3 + a_{73} y^4 + a_{74} y^6 + a_{75} Ch(M_1 y) + a_{76} Sh(M_1 y)$$
$$+ a_{77} Sh(\beta_1 y) + a_{78} Ch(\beta_1 y) + a_{79} y Ch(M_1 y) + a_{80} y Sh(M_1 y)$$
$$+ a_{81} y Sh(\beta_1 y) - a_{82} y Ch(\beta_1 y) + a_{83} y + a_{84}$$

$$C_{10} = b_{33} Ch(\beta_1 y) + b_{34} Sh(\beta_1 y) + \varphi_3(y)$$

$$C_{10} = b_{33} Ch(\beta_1 y) + b_{34} Sh(\beta_1 y) + \varphi_3(y)\varphi_3(y) = -b_{13} - b_{14} y - b_{15} y^2 - b_{16} y^4 + b_{17} Ch(M_1 y) + b_{18} Sh(M_1 y) + b_1 y Sh(\beta_1 y)$$
$$+ b_{20} Ch(\beta_2 y) + b_{21} Ch(\beta_3 y) + b_{22} Sh(\beta_2 y) + b_{23} Sh(\beta_3 y) + b_{24} Ch(2\beta_1 y)$$
$$+ b_{25} Sh(2\beta_1 y) + b_{26} y Ch(M_1 y) + b_{27} y^2 Ch(\beta_1 y) + b_{28} y^2 Sh(\beta_1 y) + b_{29} y^2 Sh(M_1 y)$$
$$+ b_{30} y^2 y^2 Ch(M_1 y) + b_{31} y^3 Ch(\beta_1 y) + b_{32} y Ch(\beta_1 y)$$

$$\psi_{10} = db_8 Ch(M_1 y) + b_9 Sh(M_1 y) + b_{10} y + b_{11} + \phi(y)$$

$$\varphi_4(y) = d_{28} y + d_{29} y^2 + d_{30} y^3 + d_{31} y^4 + d_{32} y^5 + d_{33} y^6 + d_{34} y^7 + (d_{35} y + d_{39} y^2 + d_{53} y^3) Ch(M_1 y)$$
$$+ (d_{36} y + d_{40} y^2 + d_{52} y^3)\ Sh(M_1 y) + (d_{37} + d_{42} y^2 + d_{50} y^3 + d_{54} y^4) Ch((\beta_1 y)$$
$$+ (d_{38} + d_{41} y^2 + d_{51} y^3 + d_{55} y^4) Sh(\beta_1 y) + d_{45} y^S Ch(\beta_2 y)$$
$$+ d_{44} Sh(\beta_2 y) + d_{45} Sh(\beta_3 y) + d_{46} Ch(\beta_2 y) + d_{47} y Ch(\beta_2 y) + d_{48} Sh(2\beta_1 y) + d_{49} Ch(2\beta_1 y)$$

where $a_1, a_2, ...a_{75}, b_1, b_2, ...b_{53}$ are constants involving the parameters.

5. NUSSELT NUMBER and SHERWOOD NUMBER

The local rate of heat transfer coefficient Nusselt number (Nu) on the walls has been calculated using the formula

$$Nu = \frac{1}{\theta_m - \theta_w}\left(\frac{\partial \theta}{\partial y}\right)_{y=\pm 1} \qquad \theta_m = 0.5\int_{-1}^{1} \theta\, dy$$

and the corresponding expressions are

$$(N\,u)_{y=+1} = \frac{(-1 + Ec\, d_{64} + \delta\, d_{66}}{(\theta_{m8} - \gamma(x))} \qquad (N\,u)_{y=-1} = \frac{(1 + Ec\, d_{64} + \delta\, d_{67})}{(\theta_m - \gamma(x))},$$

$$\theta_m = d_{68} + Ec\, d_{69} + \delta\, d_{70}$$

The local rate of mass transfer coefficient (Sherwood Number Sh) on the walls has been calculated using the formula

$$Sh = \frac{1}{C_m - C_w}\left(\frac{\partial C}{\partial y}\right)_{y=\pm 1}$$

where $C_m = 0.5\int_{-1}^{1} C\, dy$ and the corresponding expressions are

$$(Sh)_{y=+1} = \frac{(d_{71} + Ec\, d_{73} + \delta\, d_{75})}{(C_m - 1)}, \quad (Sh)_{y=-1} = \frac{(d_{72} + Ec\, d_{74} + \delta\, d_{76})}{(C_m)},$$

where $C_m = d_{77} + Ec\, d_{78} + \delta\, d_{79}$

where $d_1.d_2, ..., d_{79}$ are constants .

6. DISCUSSION OF THE NUMERICAL RESULTS

In this analysis we investigate the combined influence of chemical reaction thermal radiation sorret effect and dissipation on convective heat and mass transfer flow of viscous electrically conducting fluid in a vertical channel whose walls are maintained at non uniform temperature.

The axial velocity 'u' is exhibited in figures (1-5) for different values of, S_o, γ, N_1, E_c and $\alpha 1$. We found that the actual axial flow is in the vertically upward direction and hence u < 0 represents a reversal flow. The effect of Soret parameter S_o on 'u' is exhibited in fig 6. It is found that 'u' exhibits a reversal flow for $S_o < 0$ and magnitude of u experiences an enhancement with increase in |So| (fig.1) Fig 2 represents 'u' with chemical reaction parameter γ. The axial velocity enhances in the degenerating chemical reaction case. Fig 3 represents u with radiation parameter N_1. It is found that higher the radiative heat flux larger the axial velocity in the flow region. The effect of viscous dissipation on 'u' is shown in fig 4. It is found that higher dissipative heat larger 'u' in a flow region. Fig 9(a) represents u with amplitude α_1 of the boundary temperature it is found that $|u|$ depreciates marginally with increase in α_1. Fig 5 represents with α_1 it can be seen from the profiles that $|v|$ depreciates with increase in α_1

The secondary velocity 'v' which arises due to the non uniform boundary temperature is exhibited in fig (6-10) for different parametric values. From fig 6 we notice that |v|depreciates with increase with $S_o \geq 0$ and enhances with $|So|$. Fig 7 represents v with chemical reaction parameter |v|. It can be seen from the profiles that |v|depreciates with increase in $\gamma \leq 2.5$ and for higher $\gamma \geq 3.5$ we notice an enhancement in |v|. Fig 8 represents v with radiation parameter N_1. It is found that higher the radiative heat flux smaller |v| in a flow region. Also higher the dissipative heat smaller |v|in the flow region(fig 9). Fig 10 represents with α_1 it can be seen from the profiles that $|v|$ depreciates with increase in α_1

The non- dimensional temperature θ is exhibited in figure 11 - 15 for different parametric values. It is found that the non dimensional temperature positive or negative according as the actual temperature is greater or lesser that T_e. The actual temperature depreciates with increase in |So| (fig.11) . Fig 12 represents θ with chemical reaction parameter γ . It is observed that the actual temperature enhances in the degeneration chemical reaction case. From fig 13 and 14 we

notice that the actual temperature enhances with increase in radiative parameter N_1 and the Eckert number E_c. Fig 15 represents θ with α_1, Hhigher the amplitude $\alpha_1$for the boundary temperature larger the actual temperature .

The non- dimensional concentration 'C' is shown in fig 16-21 for different parametric values. We follow the concentration is positive or negative according as the actual concentration is greater/lesser than C1, the concentration on the boundary y=-1. Fig 16 represents C with S_c .It is found that lesser the molecular diffusivity smaller the actual concentration in the flow region. Fig 17 represents 'C' with Soret parameter S_o .It is found that the actual concentration depreciates in the left half and enhances in the right half with increase in $S_o > 0$ while for $|So|$ <0. We notice that an enhancement in the left half and depreciates in the right half..From fig 18 we notice that a depreciation in the actual concentration in the degenerating chemical reaction case. Fig 19 represents the radiation parameter N_1 higher the radiative flux and larger the actual concentration. Also it enhances with increase in E_c (fig 20). Fig 21 represents 'C' with α_1. we notice an enhancement in the actual concentration with the increase in amplitude α_1.0

The rate of heat transfer (Nusselt number) at y=±1. It is exhibited in the tables (1-6) for different parametric values. We found that the rate of heat transfer depreciates with G>0 and enhances with G < 0 at y = ±1 When the molecular buoyancy force dominates over the thermal buoyancy force the rate of heat transfer enhances when the buoyancy forces acts in the same direction and for the forces acting in opposite direction it depreciates at both the walls (tab 1&4) with respect to S_c we notice that the rate of heat transfer enhances with increase in Sc at both the walls in the heating case while in the cooling case it depreciates with the Sc ≤ 0.6 and enhances with Sc ≥ 1.5 the rate of heat transfer depreciates for G>0 and enhances for G<0 with increase in Sc ≥0 at both the walls while a reversed effect is noticed in the behavior of |Nu| with increase in |So| The variation of Nu with chemical reaction parameter ɣ shows that at y= +1, |Nu| enhances for G>0 and depreciates with ɣ ≤ 1.5 while it enhances with higher ɣ ≥2.5(tab 1&4). The variation of Nu with heat source parameter α shows that the rate of heat transfer depreciates with increase in α > 0 and enhances with |α| at both the walls. Also higher the dilation of the channel walls smaller the rate of heat transfer at y=±1. With respect to Eckert number Ec it can be seen that the rate of heat transfer experiences the enhancement in the heat case and depreciates in the cooling case at both the walls (tab 3&6).

The rate of mass transfer at the y=±1is shown in tables (7-10) for different parametric values. It is found that the rate of mass transfer enhances with increase in G>0 and depreciates with G<0 at both the walls. With respect to S_c it can be seen that lesser the molecular diffusibility smaller |Sh| and for further lowering of the molecular diffusibility, larger |Sh| at y=+1, y=-1. Also |Sh| depreciates with increase in $S_o > 0$ and enhances with $|So|$ at both the walls. The variation of Sh with chemical reaction ɣ shows that the rate of mass transfer depreciates with ɣ≤ 1.5 and enhances with ɣ<2.5 while at y=-1, |Sh| depreciates with increase in ɣ for all G (tab 4 &9). The variation of Sh with the amplitude α_1 of the boundary temperature shows that the higher the amplitude α_1 larger the |Sh| at y=±1 with respect to E_c we find that higher dissipative heat larger |Sh| at y=±1 and smaller at y=-1 for all G (tab 8&10).

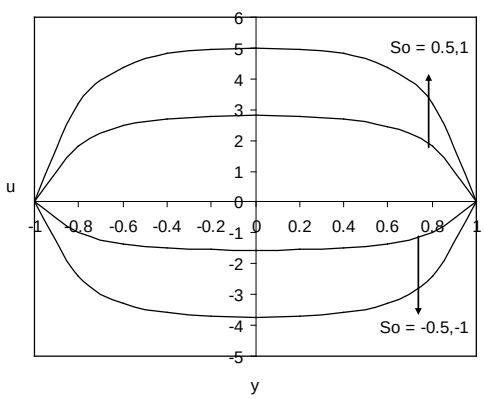

Fig. 1 : Variation of u with S_0
G=2, R = 35, M =5, N=1, Sc=1.3,
γ=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

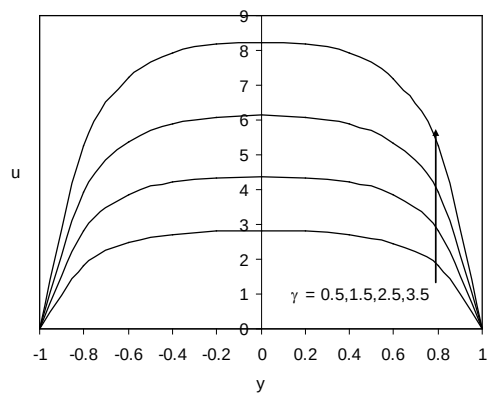

Fig. 2 : Variation of u with γ
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5,
N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

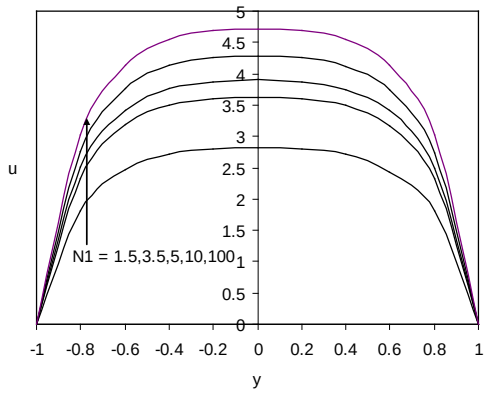

Fig. 3 : Variation of u with N_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, Ec=0.01, α_1=0.3, x=π/4

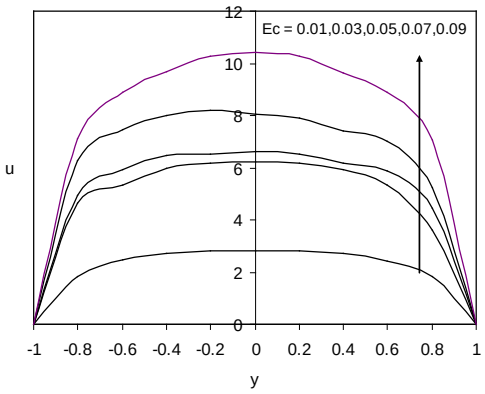

Fig. 4 : Variation of u with Ec
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, α_1=0.3, x=π/4

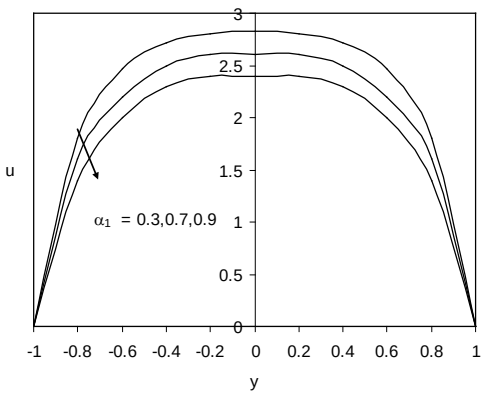

Fig. 5 : Variation of u with α_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, Ec=0.01, x=π/4

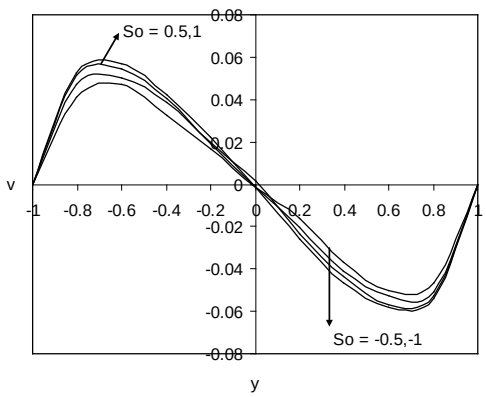

Fig. 6 : Variation of v with S_0
G=2, R = 35, M =5, N=1,
γ=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

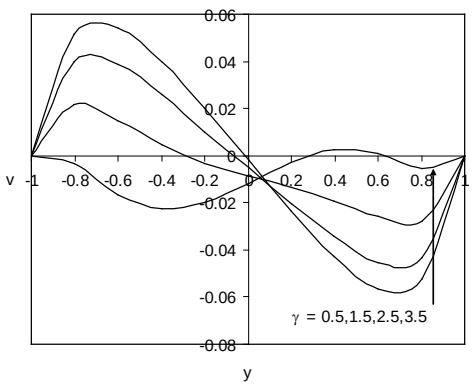

Fig. 7 : Variation of v with γ
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

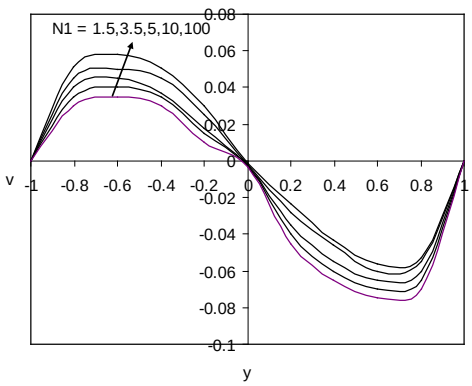

Fig. 8 : Variation of v with N_1
G=2, R = 35, M =5, N=1, Sc=1.3, γ=0.5, Ec=0.01, α_1=0.3, x=π/4

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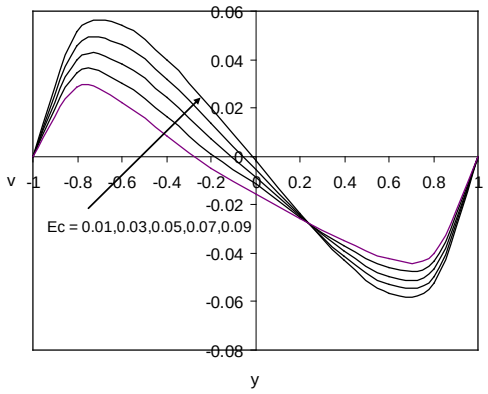

Fig. 9 : Variation of v with Ec
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, α_1=0.3, x=π/4

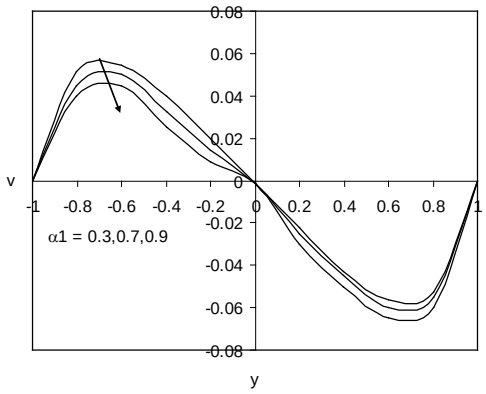

Fig. 10 : Variation of v with α_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, Ec=0.01, x=π/4

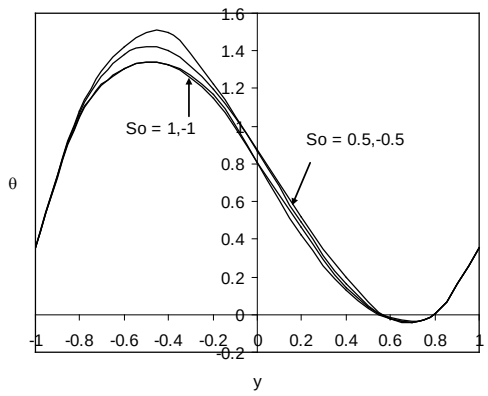

Fig. 11 : Variation of θ with S_0
G=2, R = 35, M =5, N=1, Sc=1.3, γ=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

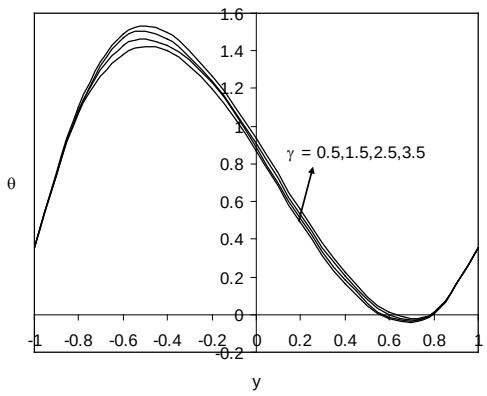

Fig.12 : Variation of θ with γ
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

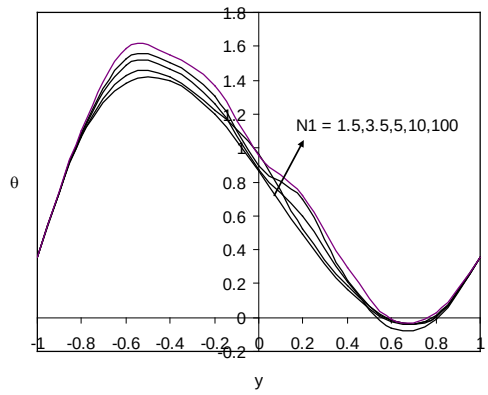

Fig. 13 : Variation of θ with N_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, Ec=0.01, α_1=0.3, x=π/4

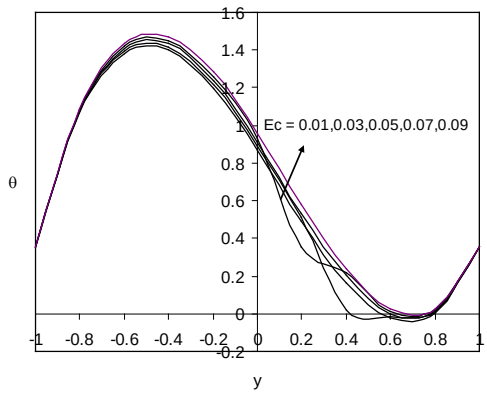

Fig. 14 : Variation of θ with Ec
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, α_1=0.3, x=π/4

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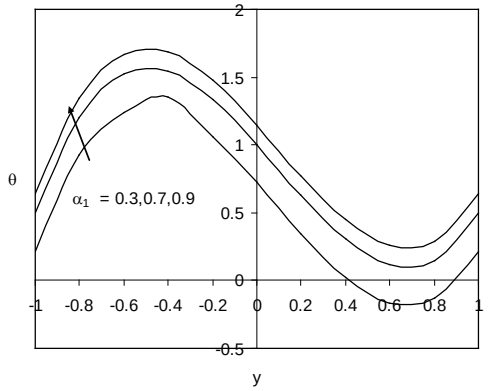

Fig. 15 : Variation of θ with α_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, Ec=0.01, x=π/4

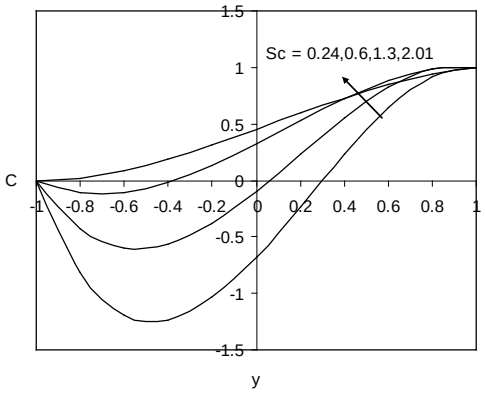

Fig. 16 : Variation of C with Sc
G=2, R = 35, M =5, N=1, S_0=0.5, γ=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

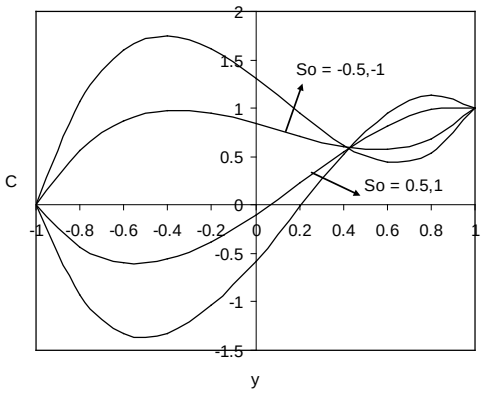

Fig. 17 : Variation of C with S_0
G=2, R = 35, M =5, N=1, Sc=1.3, γ=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

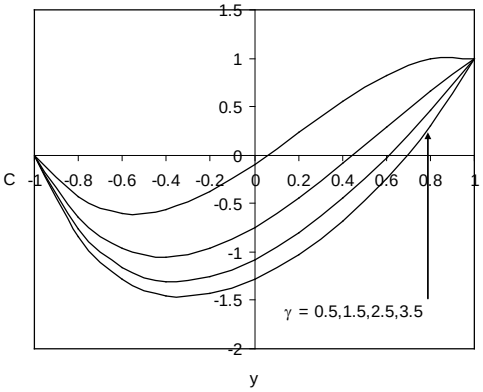

Fig. 18 : Variation of C with γ
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, N_1=1.5, Ec=0.01, α_1=0.3, x=π/4

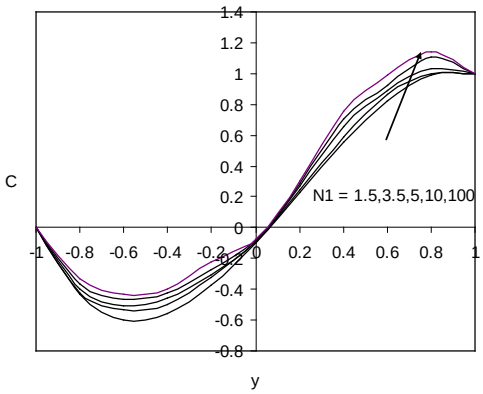

Fig. 19 : Variation of C with N_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, Ec=0.01, α_1=0.3, x=π/4

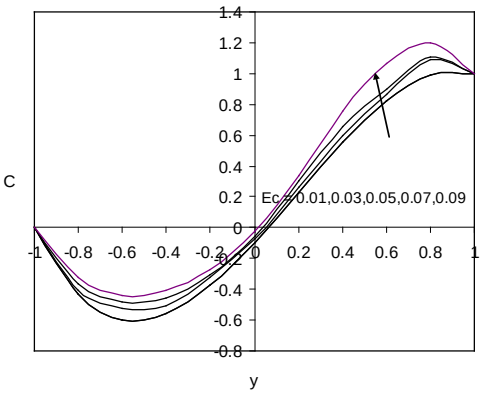

Fig. 20 : Variation of C with Ec
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5, γ=0.5, N_1=1.5, α_1=0.3, x=π/4

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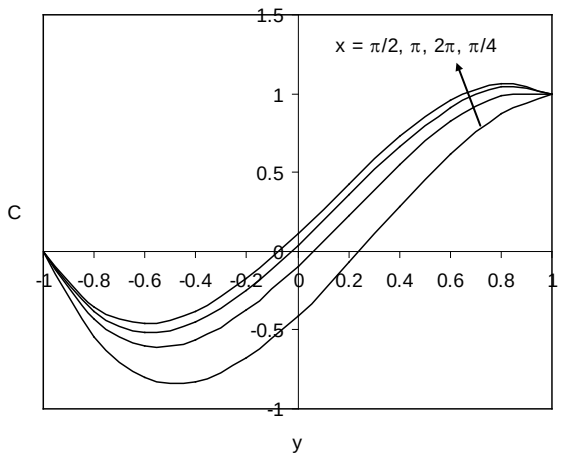

Fig. 21 : Variation of C with α_1
G=2, R = 35, M =5, N=1, Sc=1.3, S_0=0.5,
γ=0.5, N_1=1.5, Ec=0.01, x=π/4

Table - 1
Nusselt number at y = +1

G	I	II	III	IV	V	VI	VII	VIII	IX	X
10^3	-1.3829	-1.6758	-467.197	-20.077	-1.1987	-1.8401	-2.0543	-1.7010	-1.7111	-1.7409
$3x10^3$	-1.1426	-1.7279	-1.1977	-38.4521	-0.7716	-2.0525	-2.4807	-1.7475	-1.7289	-1.7233
$5x10^3$	-0.9025	-1.7803	-0.9839	-56.7548	-0.3462	-2.2643	-2.9067	-1.7937	-1.7466	-1.7136
-10^3	-1.8643	-1.5730	-2.8433	16.8787	-2.0579	-1.4144	-1.2002	-1.6077	-1.6754	-1.7189
$-3x10^3$	-2.1053	-1.5223	-2.0597	35.4747	-2.4899	-1.2010	-0.7728	-1.5608	-1.6574	-1.7067
$-5x10^3$	-2.3466	-1.4723	-2.2767	54.0930	-2.9230	-0.9873	-0.3448	-1.5137	-1.6394	-1.6951
Sc	0.24	0.6	1.3	2.01	1.3	1.3	1.3	1.3	1.3	1.3
S_0	0.5	0.5	0.5	0.5	1	-0.5	-1	0.5	0.5	0.5
γ	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	2.5	3.5

Table - 2
Nusselt number at y = +1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	-4.197	-1.4095	-1.4066	-1.4178	-1.4206	-1.4233	-1.4204	-1.4042	-1.3960
$3x10^3$	-1.1977	-1.1950	-1.1922	-1.2031	-1.2058	-1.2083	-1.2059	-1.1896	-1.1813
$5x10^3$	-0.9839	-0.9814	-0.9788	-0.9887	-0.9910	-0.9933	-0.9921	-0.9756	-0.9673
-10^3	-1.8433	-1.8408	-1.8384	-1.8483	-1.8508	-1.8533	-1.8513	-1.8353	-1.8274
$-3x10^3$	-2.0597	-2.0576	-2.0556	-2.0639	-2.0661	-2.0683	-2.0673	-2.0518	-2.0440
$-5x10^3$	-2.2767	-2.2751	-2.2737	-2.2799	-2.2816	-2.2833	-2.2845	-2.2689	-2.2612
α	2	4	6	-2	-4	-6	2	2	2
α_1	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.7	0.9

Table -3
Nusselt number at y = +1

G	I	II	III	IV	V	VI	VII	VIII
10^3	-375.53	-4.1970	-546.32	-0.699	-7.1252	-1.5569	-1.5857	-1.5981
$3x10^3$	-1.1974	-1.1977	-1.1979	-1.1979	-1.1986	-1.4853	-1.5428	-1.5675
$5x10^3$	-0.9836	-0.9839	-0.9841	-0.9842	-0.9846	-1.4139	-1.5000	-1.5369
-10^3	-1.8433	-1.8436	-1.8439	-1.8448	-1.8459	-1.7006	-1.6720	-1.6597
$-3x10^3$	-2.0584	-2.0597	-2.0602	-2.0605	-2.0609	-1.7728	-1.7153	-1.6907
$-5x10^3$	-2.2750	-2.2767	-2.2774	-2.2779	-2.2781	-1.8452	-1.7587	-1.7217
N_1	0.5	1.5	3.5	10	100	1.5	1.5	1.5
Ec	0.05	0.05	0.05	0.05	0.05	0.03	0.05	0.07

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Table - 4
Nusselt number at y = -1

G	I	II	III	IV	V	VI	VII	VIII	IX	X
10^3	1.3829	1.6759	47.197	6.0773	1.1987	1.8402	2.0543	1.7011	1.7111	1.7408
$3x10^3$	1.1426	1.7279	2.1977	3.4522	0.7715	2.0524	2.4808	1.7475	1.7289	1.7234
$5x10^3$	0.9025	1.7803	2.9838	3.7547	0.3462	2.2643	2.9068	1.7937	1.7466	1.7136
-10^3	1.8643	1.5730	1.8433	6.8787	2.0580	1.4145	1.2003	1.6077	1.6754	1.7189
$-3x10^3$	2.1053	1.5224	2.0597	4.4548	2.4900	1.2011	0.7727	1.5608	1.6574	1.7067
$-5x10^3$	2.3467	1.4723	2.2767	3.0930	2.9234	0.9873	0.3447	1.5138	1.6394	1.6951
Sc	0.24	0.6	1.3	2.01	1.3	1.3	1.3	1.3	1.3	1.3
S_0	0.5	0.5	0.5	0.5	1	-0.5	-1	0.5	0.5	0.5
γ	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	2.5	3.5

Table - 5
Nusselt number at y = -1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	2.1972	1.6095	1.4066	1.4179	1.4206	1.4234	1.4204	1.4042	1.3960
$3x10^3$	1.1978	1.1950	1.1922	1.2032	1.2058	1.2084	1.2059	1.1896	1.1813
$5x10^3$	0.9839	0.9814	0.9789	0.9888	0.9911	0.9933	0.9921	0.9757	0.9672
-10^3	1.8433	1.8409	1.8384	1.8483	1.8508	1.8534	1.8513	1.8354	1.8275
$-3x10^3$	2.0597	2.0576	2.0556	2.0640	2.0662	2.0684	2.0676	2.0519	2.0441
$-5x10^3$	2.2767	2.2751	2.2737	2.2800	2.2816	2.2834	2.2846	2.2689	2.2613
α	2	4	6	-2	-4	-6	2	2	2
α_1	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.7	0.9

Table -6
Nusselt number at y = -1

G	I	II	III	IV	V	VI	VII	VIII
10^3	3.53	4.1971	6.32	7.69	8.69	1.5568	1.5858	1.5982
$3x10^3$	1.1974	1.1977	1.1979	1.1980	1.1986	1.4852	1.5428	1.5675
$5x10^3$	0.9836	0.9839	0.9841	0.9843	0.9864	1.4139	1.5001	1.5370
-10^3	1.8424	1.8433	1.8436	1.8438	1.8442	1.7006	1.6720	1.6598
$-3x10^3$	2.0584	2.0597	2.0602	2.0605	2.0627	1.7728	1.7153	1.6907
$-5x10^3$	2.2751	2.2767	2.2774	2.2779	2.2792	1.8452	1.7588	1.7217
N_1	0.5	1.5	3.5	10	100	1.5	1.5	1.5
Ec	0.05	0.05	0.05	0.05	0.05	0.03	0.05	0.07

Table - 7
Sherwood number (Sh) at y = +1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	-0.60267	-0.59857	-2.48053	-0.81248	-0.07467	-0.33832	2.8892	1.44859	1.56721
$3x10^3$	-0.60158	-0.59309	-2.48868	-0.81429	-0.07453	-0.83748	2.8924	1.44986	1.56810
$5x10^3$	-0.60029	-0.59266	-2.49683	-0.81610	-0.07439	-0.33665	2.89553	1.4514	1.56898
-10^3	-0.60429	-0.59429	-0.46423	-0.80886	-0.07496	-0.34000	2.88301	1.44603	1.56544
$-3x10^3$	-0.60481	-0.59464	-2.45608	-0.80704	-0.07512	-0.34087	2.87987	1.4447	1.56455
$-5x10^3$	-0.60514	-0.59898	-2.44792	-0.80523	-0.07528	-0.34667	2.87674	1.4434	1.56367
Sc	0.24	0.6	1.3	2.01	1.3	1.3	1.3	1.3	1.3
S_0	0.5	0.5	0.5	0.5	1	-0.5	-1	0.5	0.5
γ	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	2.5

Table - 8
Sherwood number (Sh) at y = +1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	-1.02306	-1.02318	-1.02231	-1.02275	-1.02268	-1.02259	-0.8560	-1.1812	-1.3312
$3x10^3$	-1.02417	-1.02428	-1.02440	-1.02366	-1.02352	-1.02359	-0.8580	-1.1819	-1.3318
$5x10^3$	-1.02526	-1.02536	-1.02546	-1.02056	-1.02436	-1.02408	-0.8599	-1.1827	-1.3323
-10^3	-1.02081	-1.02094	-1.02106	-1.2091	-1.02099	-1.02109	-0.8521	-1.1796	-1.3301
$-3x10^3$	-1.01967	-1.01979	-1.01991	-1.0199	-1.02013	-1.02034	-0.8501	-1.1789	-1.3295
$-5x10^3$	-1.01853	-1.01863	-1.01872	-1.01906	-1.01927	-1.01937	-0.8481	-1.1781	-1.3289
Ec	0.03	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05
N_1	0.5	0.5	0.5	1.5	3.5	10	0.5	0.5	0.5
α_1	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.7	0.9

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Table - 9
Sherwood number (Sh) at y =-1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	-21.9930	-1.1857	-8.4376	-0.9373	-0.2605	-0.3930	1.0916	0.7443	0.6445
$3x10^3$	-21.9499	-1.1838	-8.4738	-0.9392	-0.2606	-0.3931	1.0936	0.7457	0.6453
$5x10^3$	-21.9165	-1.1819	-8.5100	-0.9411	-0.2608	-0.3929	1.0955	0.7468	0.6461
-10^3	-22.1081	-1.1899	-8.3653	-0.9335	-0.2602	-0.3934	1.0878	0.7423	0.6428
$-3x10^3$	-22.1801	-1.1920	-8.3292	-0.9316	-0.2600	-0.3956	-1.0858	0.7412	0.6419
$-5x10^3$	-22.2616	-1.1943	-8.2931	-0.9297	-0.2598	-0.3936	1.0839	0.7401	0.6411
Sc	0.24	0.6	1.3	2.01	1.3	1.3	1.3	1.3	1.3
S_0	0.5	0.5	0.5	0.5	1	-0.5	-1	0.5	0.5
γ	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	2.5

Table - 10
Sherwood number (Sh) at y = -1

G	I	II	III	IV	V	VI	VII	VIII	IX
10^3	-1.6386	-1.6483	-1.6380	-1.6382	-1.6380	-1.6377	-1.0366	-3.1271	-12.8873
$3x10^3$	-1.6407	-1.6405	-1.6402	-1.6397	-1.6393	-1.6387	-1.0398	-3.1296	-12.8444
$5x10^3$	-1.6429	-1.6427	-1.6426	-1.6413	-1.6407	-1.6398	-1.0413	-3.1324	-12.8514
-10^3	-1.6343	-1.6341	-1.6338	-1.6352	-1.6354	-1.6357	-1.0313	-3.1221	-12.8237
$-3x10^3$	-1.6323	-1.6320	-1.6318	-1.6338	-1.6341	-1.6347	-1.0287	-3.1197	-12.8172
$-5x10^3$	-1.6303	-1.6301	-1.6299	-1.6323	-1.6329	-1.6337	-1.0261	-3.1173	-12.8108
Ec	0.03	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05
N_1	0.5	0.5	0.5	1.5	3.5	10	0.5	0.5	0.5
α_1	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.7	0.9

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