International Journal of Future Generation Communication and Networking
Vol. 13, No. 2, 2020 pp.1064-1084

Combined Effects Of Rotation And Hall Current On Mhd Convective Flow Through Porous Medium In Vertical Porous Plates With Radiative Heat Transfer

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Abstract
A theoretical investigation on the influence of radiation on free convection flow of a viscous incompressible fluid in vertical plates partly loaded with porous medium with the effect of hall current and inclined magnetic field has been presented. Here the infinite plates are moving in opposite direction and are sustained at different temperatures. The perturbation scheme has been implemented to solve the governing equations of the flow. The approximate solution for temperature and velocity distribution has been obtained and the effects of the flow parameters have been discussed graphically for possible cases
Keywords: *Magneto hydrodynamic, Vertical plates, Hall current, rotation, partly loaded porous medium, Inclined Magnetic Field.*

1. Introduction

Vertical channels are often used in numerous applications in structuring, ventilating and heating of buildings, modeling of solar system for energy conservation, drying, chemical devices, cooling electronic components, for many types of agriculture products like food grains and in packed thermal storages. The chemical process industry, centrifugation and filtration processes, food processing industry, rotating machinery and in food processing industry are the few applications of rotating flow with hall effect in porous media to engineering disciplines. Convective flows in rotating parallel plates with Hall effect and temperature differences have been discussed.

Chauhan and Jain (2005) studied three dimensional MHD steady flow of a viscous incompressible fluid over a highly porous layer. Prasad and Reddy (2008), explained about radiation effects on an unsteady MHD convective heat and mass transfer flow past a semi-infinite vertical permeable moving plate embedded in a porous medium. Chauhan and Agrawal (2010) discussed on the effects of hall current on MHD flow in a rotating channel partially filled with a porous medium. Gupta, et al., (2011) studied about free convection flow between vertical plates moving in opposite direction and partially filled with porous medium. Stamenkovic (2012) illustrated about Magneto hydrodynamic flow and heat transfer of two immiscible fluids with induced magnetic field effects. The MHD flow in a region partially filled with porous medium and bounded by two periodically heated oscillating plates was illustrated by Chaudharyi and Pawan Kumar Sharma (2015). Mixed convection radiating flow and heat transfer in a vertical channel partially filled with a Darcy-Forchheimer porous substrate was discussed by Adeniyan, et al.,(2016). Heat and mass transfer in free convective flow of walter’s liquid model-B through rotating vertical channel, was learnt by Pooja Sharma(2017). Hall effects on unsteady MHD oscillatory free convective flow of second grade fluid through porous medium between two vertical plates was illustrated by Veera Krishna and Subba Reddy(2018). Inclined magnetic field, thermal radiation, and hall current effects on mixed convection flow between vertical parallel plates were illustrated by Kaladhar and Madhusudhan Reddy (2019).

The study contributed here analyzes about the incompressible and electrically conducting fluid in moving parallel plates with radiation and Hall effect. The infinite porous plates are sustained with distinct temperatures and electrically non - conducting.

ISSN: 2233-7857 IJFGCN

2. PROBLEM DEVELOPMENT

The impact of radiation on free convective flow of viscous, electrically conducting fluid in vertical porous channel separated with porous, clear medium is discussed. Hall effect and inclined magnetic field is also considered. It is assumed that the system is rotating about its axis perpendicular to the plates with Ώ, (the uniform angular velocity). The plates are moving in upward and downward direction with velocities and the plates are maintained at constant temperature and are high enough to emit radiation. Let $\overline{U}_f$ and $\overline{U}_p$ be the velocities of the two vertical plates..Along the X-axis the channel is oriented vertically upward and Y axis normal to it. The velocity components in the clear medium is denoted by $\overline{U}_f$, $\overline{V}_f$ and in the porous region it is given by $\overline{U}_p$, $\overline{V}_p$ in the X,Y directions respectively. $\overline{T}_f$ and $\overline{T}_p$ are the temperatures of the plates situated at $(\overline{Y}=0)$ and $(\overline{Y}=H)$.

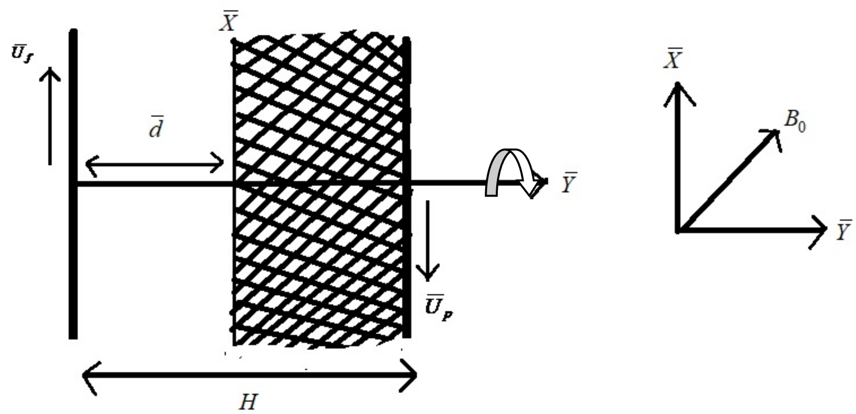

Figure 1 Schematic Configuration

3. MHD EQUATIONS AND METHODOLOGY

The mathematical formulation of the governing momentum and energy equations with the pertinent parameters of the above flow configuration are written as:

Fluid Phase

$$-\frac{2}{\upsilon}\Omega\overline{V}_f+\frac{V_0}{\upsilon}\frac{d\overline{U}_f}{dy}=\frac{\partial^2\overline{U}_f}{\partial\overline{y}^2}+\frac{g\beta}{\upsilon}(\overline{T}_f-\overline{T}_c)-\frac{B^2{}_0\mu^2\sigma\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(\overline{U}_f+\overline{V}_f m\sin\theta)$$

(1.a)

$$\frac{2}{\upsilon}\Omega\overline{U}_f+\frac{V_0}{\upsilon}\frac{d\overline{V}_f}{dy}=\frac{\partial^2\overline{V}_f}{\partial\overline{y}^2}+\frac{g\beta}{\upsilon}(\overline{T}_f-\overline{T}_c)+\frac{B^2{}_0\mu^2\sigma\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(\overline{U}_f m\sin\theta-\overline{V}_f)$$

(1.b)

$$V_0\frac{d}{d\overline{y}}(\overline{T}_f-\overline{T}_c)=\frac{1}{\rho c_p}\left\{\left(\frac{d\overline{U}_f}{d\overline{y}}\right)^2+\left(\frac{d\overline{V}_f}{d\overline{y}}\right)^2\right\}+\frac{k}{\rho c_p}\frac{d^2}{d\overline{y}^2}(\overline{T}_f-\overline{T}_c)-\frac{1}{\rho c_p}\frac{dq_r}{d\overline{y}}$$

(2)

Porous Phase

$$-\frac{2}{\upsilon}\Omega\overline{V}_p+\frac{V_0}{\upsilon}\frac{d\overline{U}_p}{dy}=\frac{\partial^2\overline{U}_p}{\partial\overline{y}^2}+\frac{g\beta}{\upsilon}(\overline{T}_p-\overline{T}_c)-\frac{B^2{}_0\mu^2\sigma\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(\overline{U}_p+\overline{V}_p m\sin\theta)-\frac{\overline{U}_p}{\overline{k}} \quad (3.a)$$

$$\frac{2}{\upsilon}\Omega\overline{U}_p+\frac{V_0}{\upsilon}\frac{d\overline{V}_p}{dy}=\frac{\partial^2\overline{V}_p}{\partial\overline{y}^2}+\frac{g\beta}{\upsilon}(\overline{T}_p-\overline{T}_c)+\frac{B^2{}_0\mu^2\sigma\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(\overline{U}_p m\sin\theta-\overline{V}_p)-\frac{\overline{V}_p}{\overline{k}} \tag{3.b}$$

$$V_0\frac{d}{d\overline{y}}(\overline{T}_f-\overline{T}_c)=\frac{\mu}{\rho c_p}\left\{\left(\frac{d\overline{U}_p}{d\overline{y}}\right)^2+\left(\frac{d\overline{V}p}{d\overline{y}}\right)^2\right\}+\frac{k}{\rho c_p}\frac{d^2}{d\overline{y}^2}(\overline{T}_f-\overline{T}_c)-\frac{1}{\rho c_p}\frac{dq_r}{d\overline{y}}-\frac{1}{\rho c_p}\left[\frac{\overline{U}_p^2}{\overline{k}}+\frac{\overline{V}_p^2}{\overline{k}}\right]=0 \tag{4}$$

Boundary conditions:

$$\overline{y}=0;\overline{U}_f=\frac{H^2}{\upsilon}g\beta(\overline{T}_h-\overline{T}_c)u_0;\overline{V}_f=\frac{g\beta H^2}{\upsilon}(\overline{T}_h-\overline{T}_c)v_0:\overline{T}_f=(\overline{T}_c+(\overline{T}_h-\overline{T}_c)A)$$

$$\overline{y}=H;\overline{U}_p=\frac{-H^2}{\upsilon}g\beta(\overline{T}_h-\overline{T}_c)u_0;\overline{V}_p=\frac{-g\beta H^2}{\upsilon}(\overline{T}_h-\overline{T}_c)v_0;\overline{T}_p=(\overline{T}_c+(\overline{T}_h-\overline{T}_c)B)$$

$$\overline{y}=\overline{d};\overline{U}_f=\overline{U}_p;\overline{V}_f=\overline{V}_p:\frac{d\overline{U}_f}{d\overline{y}}=\frac{d\overline{U}_p}{d\overline{y}};\overline{U}_f=\overline{U}_p;\frac{d\overline{T}_f}{d\overline{y}}=\frac{d\overline{T}_p}{d\overline{y}};(\overline{T_f})=(\overline{T_p}); \tag{5}$$

Dimensionless parameters:

$$U_f=\frac{\upsilon\overline{U}_f}{g\beta H^2}\frac{1}{(\overline{T}_h-\overline{T}_c)},V_f=\frac{\upsilon\overline{V}_f}{g\beta H^2}\frac{1}{(\overline{T}_h-\overline{T}_c)}\theta_f=\frac{1}{(\overline{T}_h-\overline{T}_c)}(\overline{T}_f-\overline{T}_c);Da=\frac{\overline{k}}{H^2};y=\frac{1}{H}\overline{y};d=\frac{\overline{d}}{H};R_0=\frac{\Omega}{\upsilon}H^2$$

$$U_p=\frac{\upsilon\overline{U}_p}{g\beta H^2}\frac{1}{(\overline{T}_h-\overline{T}_c)},V_p=\frac{\upsilon\overline{V}_p}{g\beta H^2}\frac{1}{(\overline{T}_h-\overline{T}_c)},\theta_p=\frac{1}{(\overline{T}_h-\overline{T}_c)}(\overline{T}_p-\overline{T}_c);N=\frac{g^2\beta^2H^4}{k\upsilon}(\overline{T}_h-\overline{T}_c);M=\frac{\sigma B_0^2h^2}{\upsilon}$$

(6)

The conveniently transformed dimensionless form of the equations (1.a) to (4) can be written as:

Fluid Phase

$$-2R_0V_f+\lambda\frac{dU_f}{dy}=\frac{d^2U_f}{dy^2}+\theta_f-\frac{M\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(U_f+V_f m\sin\theta)$$

(7)

$$-2R_0U_f+\lambda\frac{dV_f}{dy}=\frac{d^2V_f}{dy^2}+\theta_f+\frac{M\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(U_p m\sin\theta-V_p)$$

(8)

$$P_r\lambda\frac{d\theta_f}{dy}=\frac{d^2\theta_f}{dy^2}+N\left\{\left(\frac{dU_f}{dy}\right)^2+\left(\frac{dV_f}{dy}\right)^2\right\}-R\theta_f$$

(9)

Porous Phase

$$-2R_0V_p+\lambda\frac{dU_p}{dy}=\frac{d^2U_p}{dy^2}+\theta_p-\left[\frac{M\sin\theta}{\rho\upsilon(1+m^2\sin^2\theta)}(U_p+V_p m\sin\theta)+\frac{1}{Da}u_p\right]$$

(10)

$$-2R_0U_p+\lambda\frac{dV_p}{dy}=\frac{d^2V_p}{dy^2}+\left[\frac{1}{Da}V_p+\frac{M\sin\theta}{(1+m^2\sin^2\theta)}(U_p m\sin\theta-V_p)\right]$$

(11)

$$P_r\lambda\frac{d\theta_p}{dy}=\frac{d^2\theta_p}{dy^2}+N\left\{\left(\frac{dU_p}{dy}\right)^2+\left(\frac{dV_p}{dy}\right)^2\right\}-R\theta_p+\frac{N}{Da}\left(U_p^2+V_p^2\right) \tag{12}$$

The obtained dimensionless boundary conditions are:

$$y=0;\,U_f=u_0;V_f=v_0;\theta_f=A$$

$$y=1;U_p=-u_0;V_p=-v_0;\theta_f=B$$

$$y=d;U_f=U_p;\frac{d}{dy}U_f=\frac{d}{dy}U_p;V_f=V_p;\frac{d}{dy}V_f=\frac{d}{dy}V_p$$

$$y=d\,;\theta_f=\theta_p;\frac{d}{dy}\theta_f=\frac{d}{dy}\theta_p \tag{13}$$

4. METHODOLOGY OF THE PROBLEM

$$Let\quad F_f=U_f+iV_f\quad \overline{F}_f=U_f-iV_f\qquad F_p=U_p+iV_p\quad \overline{F}_p=U_p-iV_p \tag{14}$$

The following were obtained by substituting equation (14) in (7), (8), (10), (11) and (12). We get

$$\frac{d^2F_f}{dy^2}-\lambda\frac{dF_f}{dy}-b_1F_f=-\theta_f$$

(15)

$$\frac{d^2F_p}{dy^2}-\lambda\frac{dF_p}{dy}-b_2F_p=-\theta_p$$

(16)

$$\frac{d^2\overline{F}_f}{dy^2}-\lambda\frac{d\overline{F}_f}{dy}-b_1\overline{F}_f=-\theta_f$$

(17)

$$\frac{d^2\overline{F}_p}{dy^2}-\lambda\frac{d\overline{F}_p}{dy}-b_2\overline{F}_p=-\theta_p$$

$$Where\quad b_1=2iR_0\;+\;+\frac{M\sin\theta}{(1+m^2\sin^2\theta)}(U_p m\sin\theta-V_p),$$

(18)

$$b_2=2iR_0+\frac{1}{Da}+\frac{M\sin\theta}{(1+m^2\sin^2\theta)}(U_p m\sin\theta-V_p)$$

The relevent boundary conditions are:

$$y=0;F_f=F_0,\theta_f=A$$

$$y=d;F_f=F_p,\frac{d}{dy}F_f=\frac{d}{dy}F_p\,\theta_f=\theta_p;\frac{d}{dy}\theta_f=\frac{d}{dy}\theta_p,$$

$$y=1;F_p=-F_0,\ \theta_p=B$$

(19)

In order to solve the above equations, the following perturbation expressions were considered:

$$U_f=U_{0f}+N(U_{1f})+O(N^2)\qquad \theta_f=\theta_{0f}+N(\theta_{1f})+O(N^2)$$

$$U_p=U_{0p}+N(U_{1p})+O(N^2)\qquad \theta_p=\theta_{0p}+N(\theta_{1p})+O(N^2)$$

$$then\quad F_f=F_{of}+NF_{1f}\qquad F_p=F_{op}+NF_{1p}$$

$$\overline{F}_f=\overline{F}_{of}+N\overline{F}_{1f}\qquad \overline{F}_p=\overline{F}_{op}+N\overline{F}_{1p}$$

(20)

Invoking equation (20) in (9),(12),(15),(16),(17) and (18), we get

ISSN: 2005-4238 IJAST

$$\frac{d^2F_{0f}}{dy^2}-\lambda\frac{dF_{of}}{dy}-b_1F_{0f}+\theta_{0f}=0$$
(21)

$$\frac{d^2\overline{F}_{0f}}{dy^2}-\lambda\frac{d\overline{F}_{of}}{dy}-b_1\overline{F}_{0f}+\theta_{0f}=0$$
(22)

$$\frac{d^2F_{1f}}{dy^2}-\lambda\frac{dF_{1f}}{dy}-b_1F_{1f}+\theta_{1f}=0$$
(23)

$$\frac{d^2\overline{F}_{1f}}{dy^2}-\lambda\frac{d\overline{F}_{1f}}{dy}-b_1\overline{F}_{1f}+\theta_{1f}=0$$
(24)

$$\frac{d^2F_{op}}{dy^2}-\lambda\frac{dF_{op}}{dy}-b_2F_{op}+\theta_{op}=0$$
(25)

$$\frac{d^2\overline{F}_{op}}{dy^2}-\lambda\frac{d\overline{F}_{op}}{dy}-b_2\overline{F}_{op}+\theta_{op}=0$$
(26)

$$\frac{d^2F_{1p}}{dy^2}-\lambda\frac{dF_{1p}}{dy}-b_2F_{1p}+\theta_{1p}=0$$
(27)

$$\frac{d^2\overline{F}_{1p}}{dy^2}-\lambda\frac{dF_{1p}}{dy}-b_2\overline{F}_{1p}+\theta_{1p}=0$$
(28)

$$\frac{d^2\theta_{0f}}{dy^2}-P_r\lambda\frac{d\theta_{of}}{dy}-R\theta_{of}=0$$
(29)

$$\frac{d^2\theta_{1f}}{dy^2}-P_r\lambda\frac{d\theta_{1f}}{dy}+\left(\frac{dF_{0f}}{dy}\frac{d\overline{F}_{of}}{dy}\right)-R\theta_{1f}=0 \tag{30}$$

$$\frac{d^2\theta_{0p}}{dy^2}--P_r\lambda\frac{d\theta_{op}}{dy}-R\theta_{op}=0 \tag{31}$$

$$\frac{d^2\theta_{1p}}{dy^2}-P_r\lambda\frac{d\theta_{1p}}{dy}+\left(\frac{dF_{0p}}{dy}\frac{d\overline{F}_{op}}{dy}\right)+\frac{1}{Da}(F_{0p}\overline{F}_{op})-R\theta_{1p}=0 \tag{32}$$

Boundary conditions:

$$y=0; F_{1f}=0;\ F_{0f}=f_0$$
$$y=0; \theta_{1f}=0;\ \theta_{0f}=[A]$$
$$y=1; F_{1p}=0; F_{0p}=-f_0$$
$$y=1\theta_{1p;}=0; \theta_{0p}=[B];$$
$$y=d; F_{1f}=F_{1p}; F_{0f}=F_{0p}$$
$$y=d; \frac{dF_{1f}}{dy}=\frac{dF_{1p}}{dy}; \frac{dF_{0f}}{dy}=\frac{dF_{0p}}{dy}$$
$$y=d; \theta_{1f}=\theta_{1p}; \theta_{0f}=\theta_{0p}$$
$$y=d; \frac{d\theta_{1f}}{dy}=\frac{d\theta_{1p}}{dy}; \frac{d\theta_{0f}}{dy}=\frac{d\theta_{0p}}{dy} \tag{33}$$

Using the boundary conditions (33), the solution for equations (21) - (32) are obtained by.

$$F_{0f}=A_1e^{M_1y}+B_2e^{-M_1y}+D_{11}e^{p_1y}+D_{12}e^{p_2y} \tag{34}$$
$$\overline{F}_{0f}=A_{11}e^{M_1y}+B_{12}e^{-M_1y}+D_{11}e^{p_1y}+D_{12}e^{p_2y} \tag{35}$$
$$F_{0p}=He^{P_7y}+Ie^{P_8y}+S_{21}e^{p_1y}+S_{22}e^{p_2y} \tag{36}$$
$$\overline{F}_{0p}=H_{11}e^{P_7}+I_{12}e^{P_8y}+S_{21}e^{p_1y}+D_{22}e^{p_2y} \tag{37}$$
$$\theta_{0f}=a\ e^{P_1y}+be^{P_2y} \tag{38}$$
$$\theta_{0p}=a_{11}e^{P_1y}+b_{12}e^{P_2y} \tag{39}$$
$$\theta_{1f}=Ce^{p_3y}+Ee^{p_4y}+S_1e^{2M_1y}+S_2e^{2M_{11}y}+S_3e^{2p_3y}+S_4e^{p_2y}+S_5e^{b_1y}+S_6e^{b_2y}+S_7e^{b_3y}+S_8e^{b_4y}+S_9e^{b_5y}+S_{10}e^{b_6y} \tag{40}$$
$$\theta_{1p}=Je^{p_9y}+Le^{p_{10}y}+S_1e^{2M_1y}+S_{31}e^{2P_7y}+S_{32}e^{b_7y}+S_{33}e^{b_8y}+S_{34}e^{b_9y}+S_{35}e^{b_{10}y}+S_{36}e^{b_{11}y}+S_{37}e^{b_{12}y}+S_{38}e^{b_{13}y}+S_{39}e^{b_{14}y} \tag{41}$$
$$F_{1f}=Fe^{p_5y}+Ge^{p_6y}+S_{11}e^{2M_1y}+S_{12}e^{2M_{11}y}+S_{13}e^{2p_3y}+S_{14}e^{p_2y}+S_{15}e^{b_1y}+S_{16}e^{b_2y}+S_{17}e^{b_3y}+S_{18}e^{b_4y}+S_{19}e^{2P_1y}+S_{20}e^{2P_2y} \tag{42}$$
$$F_{1p}=Me^{p_{31}y}+Ne^{p_{12}y}+S_{40}e^{P_8y}+S_{41}e^{P_{10}y}+S_{42}e^{2p_7y}+S_{43}e^{b_7y}+S_{44}e^{b_8y}+S_{45}e^{b_9y}+S_{46}e^{b_{10}y}+S_{47}e^{b_{11}y}+S_{48}e^{b_{12}y}+S_{49}e^{2P_1y}+S_{50}e^{2P_{21}y} \tag{43}$$

Where

$b_1=M_1+M_{11}$; $b_2=M_1+P_2$; $b_3=M_{11}+P_1$; $b_4=M_{11}+P_2$; $b_5=M_1+P_1$; $b_6=P_1+P_2$
$b_7=P_7+P_{17}$; $b_8=P_7+P_{18}$; $b_9=P_7+M_1$; $b_{10}=P_7+M_{11}$; $b_{11}=P_1+P_7$; $b_{12}=P_7+P_2$
$b_{13}=P_8+P_{17}$; $b_{14}=P_8+P_{18}$; $b_{15}=P_8+M_1$; $b_{16}=P_8+M_{11}$; $b_{17}=P_8+P_1$; $b_{18}=P_8+P_2$;
$b_{19}=P_{17}+M_1$; $b_{20}=P_{18}+M_1$; $b_{21}=P_{17}+M_{11}$; $b_{22}=P_{18}+M_{11}$; $b_{23}=P_{17}+P_2$;

$S_1=-\frac{a_1a_{11}}{4M_1^2-2\Pr\lambda M_1-R}$; $S_2=-\frac{a_2a_{12}}{4M_{11}^2-2\Pr\lambda M_{11}-R}$;

$S_3=-\frac{D_1^2}{4P_1^2-2\Pr\lambda P_1-R}$; $S_4=-\frac{D_2^2}{4P_1^2-2\Pr\lambda P_2-R}$; $S_5=-\frac{(a_2a_{11}+a_1a_{12})}{b_1^2-2\Pr\lambda b_1-R}$; $S_6=-\frac{(a_1D_{12}+a_{11}a_{12})}{b_1^2-2\Pr\lambda b_2-R}$;

$S_7=-\frac{(a_2D_{11}+D_1a_{12})}{b_3^2-2\Pr\lambda b_3-R}$

$S_8=-\frac{(a_2D_2+a_{12}D_{12})}{b_4^2-2\Pr\lambda b_4-R}$; $S_9=-\frac{(a_{11}D_1+aD_{11})}{b_5^2-2\Pr\lambda b_5-R}$; $S_{10}=-\frac{(2D_{11}D_2)}{b_1^2-2\Pr\lambda b_2-R}$; $S_{11}=-\frac{S_1}{4M_1^2-2M_1\lambda-b_1}$;

$S_{12}=-\frac{S_2}{4M_1^2-2M_{11}\lambda-b_1}$; $S_{13}=-\frac{S_3}{4P_1^2-2P_1\lambda-b_1}$; $S_{14}=-\frac{S_4}{4P_2^2-4P_2\lambda-b_1}$; $S_{15}=-\frac{S_5}{b_1^2-b_1\lambda-b_1}$;

$S_{16}=-\frac{S_6}{b_2^2-b_2\lambda-b_1}$; $S_{17}=-\frac{S_7}{b_3^2-b_3\lambda-b_1}$; $S_{17}=-\frac{S_8}{b_4^2-b_4\lambda-b_1}$; $S_{19}=-\frac{S_9}{b_5^2-b_5\lambda-b_1}$;

$S_{20}=-\frac{S_{10}}{b_6^2-b_6\lambda-b_1}$;

$S_{21}=-\frac{a_{11}}{P_1^2-P_1\lambda-b_2}$; $S_{22}=-\frac{a_{12}}{P_2^2-P_2\lambda-b_2}$ $S_{23}=P_7^2HH_{11}+\frac{HH_{11}}{Da}$

$S_{24}=\frac{HI_{12}+IH_{11}}{Da}+P_7P_8(HI_{12}+IH_{11})$ $S_{25}=P_7P_1(S_{21}H+S_{21}H_{11})+\frac{(HS_{21}+S_{21}H_{11})}{Da}$

$S_{26}=P_7P_2(S_{22}H+S_{22}H_{11})+\frac{(HS_{22}+S_{22}H_{11})}{Da}$;

$S_{27}=(P_1P_8S_{21}(I+I_{12}))+\frac{(IS_{21}+S_{21}I_{12})}{Da}$; $S_{28}=(P_8P_2S_{22}(I+I_{12}))+\frac{(IS_{22}+S_{22}I_{12})}{Da}$;

$S_{29}=(2P_1P_2S_{21}S_{22})+\frac{(2S_{21}S_{22})}{Da}$; $S_{30}=P_1^2S_{21}^2$; $S_{31}=-\frac{S_{23}}{(2b_7)^2-\Pr\lambda(2b_7)-R}$;

$S_{32}=-\frac{S_{24}}{(b_7)^2-\Pr\lambda(b_7)-R}$; $S_{33}=-\frac{S_{25}}{(b_8)^2-\Pr\lambda(b_8)-R}$; $S_{34}=-\frac{S_{26}}{(b_9)^2-\Pr\lambda(b_9)-R}$;

$S_{35}=-\frac{S_{27}}{(b_{10})^2-\Pr\lambda(b_{10})-R}$; $S_{36}=-\frac{S_{28}}{(b_{11})^2-\Pr\lambda(b_{11})-R}$; $S_{37}=\frac{S_{29}}{(b_{12})^2-\Pr\lambda(b_{12})-R}$;

$S_{38}=\frac{S_{30}}{(2P_1)^2-\Pr\lambda(2P_1)-R}$; $S_{39}=\frac{S^2{}_{22}}{(2P_2)^2-\Pr\lambda(2P_2)-R}$; $S_{40}=-\frac{J}{(P_8)^2-\lambda(P_8)-b_2}$;

$S_{41}=-\frac{L}{(P_{10})^2-\lambda(P_{10})-b_2}$; $S_{42}=-\frac{S_{31}}{(2P_7)^2-\lambda(2P_7)-b_2}$; $S_{43}=-\frac{S_{32}}{(b_7)^2-\lambda(b_7)-b_2}$;

$S_{44}=-\frac{S_{33}}{(b_8)^2-\lambda(b_8)-b_2}$; $S_{45}=-\frac{S_{34}}{(b_9)^2-\lambda(b_9)-b_2}$; $S_{46}=-\frac{S_{35}}{(b_{10})^2-\lambda(b_{10})-b_2}$;

$S_{47}=-\frac{S_{36}}{(b_{11})^2-\lambda(b_{11})-b_2}$; $S_{48}=-\frac{S_{37}}{(b_{12})^2-\lambda(b_{12})-b_2}$; $S_{49}=-\frac{S_{38}}{(2P_1)^2-\lambda(P_1)-b_2}$;

$S_{50}=-\frac{S_{39}}{(2P_2)^2-\lambda(2P_2)-b_2}$

5. RESULTS AND ANALYSIS

To analysis the effect of rotation along with inclined magnetic field on magnetohydrodynamic convective flow in vertical plates which is sectioned by clear and porous region have been discussed. For healthier insight of the problem, the different parameters on primary, secondary velocities and temperature distributions are evaluated graphically. The important parameter of the flow has been discussed for different temperature situations at the plates.

In order to analyze the physical parameters involved in the flow and to study their significance, the variation of velocity and temperature profile is interpreted graphically. The plates are considered either to be heated or to be cooled. The plate y=0 is heated A=1, B=0 and y=1 is heated when A=0, B=1. The discussions for the primary and secondary velocities were made according to above said two conditions.

When A=0, B=1, the plate y=0 is heated and the effect of parameters Pr, Da, M, R, d and λ are analyzed for both primary and secondary velocities. The effect of Darcy number parameter Da is illustrated in Fig 1.2 and 1.15. It is noted that both the primary and secondary velocity profile degrades for upgrading values of Da.

In Fig 1.3 and Fig 1.14 the variation of velocities is shown clearly. The primary and secondary velocity profile seems to decrease for increasing magnetic parameter.

Fig 1.4 and Fig 1.18 illustrates the effect of parameter d. The width d graph also portrays that for step up values of d the profiles increases.

Fig 1.5 and Fig 1.17 shows that on increasing the rotation parameter (R), the profile enhances.

Fig1.6 and 1.19 it is noted that for upgrading values of the porous parameter λ, the velocities of the profile proliferate.

Fig 1.7 and 1.16 portrays the variation of physical parameter Pr. The graph degrades with upgrading values of Prandtl number Pr.

Fig 1.8 to 1.25 evident the primary and the secondary profile by considering the condition A=0, B=1, i.e, one of the plate is heated and other is cooled.

Fig 1.8, 1.13 and 1.20, 1.21 explains about the impact of parameters M and λ. For increasing value of M and λ, the profile enhances.

In Fig 1.9, 1.23, 1.10, 1.25, 1.10, 1.22, 1.12, 1.24 the variation of parameter Da, Pr, R and d are explained. On increasing Da, R and d the primary and the secondary profile upgrades while incrementing Pr values, the primary velocity graph increases whereas the secondary velocity graph decreases.

Fig 1.26 to 1.31 explains about the temperature distribution when the plate (y=0) is heated (i.e A=1, B=0) and Fig 1.32 to Fig 1.37 are used to discuss about the temperature distribution when the plate (y=1) is heated (A=0, B=1).

It is observed that the temperature profile gets elevated for increasing values of flow parameters M, Pr, λ, R, Da and d. The temperature profile seems to be enhanced for the aforementioned physical parameters that are involved in the flow.

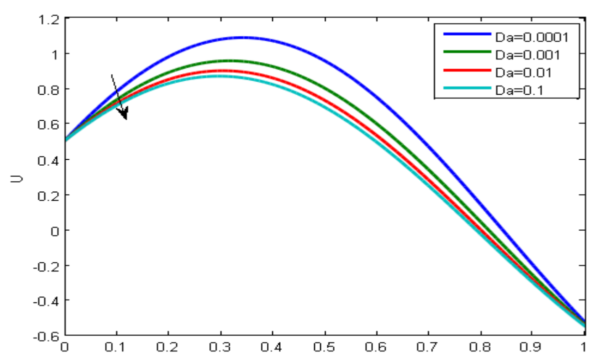

Figure 1.2: Primary velocity distribution U, for distinct value of Da, [Pr=0.10; B=0;F_0=0.50;d=0.30;M=1; A=1.0; l=0.1]

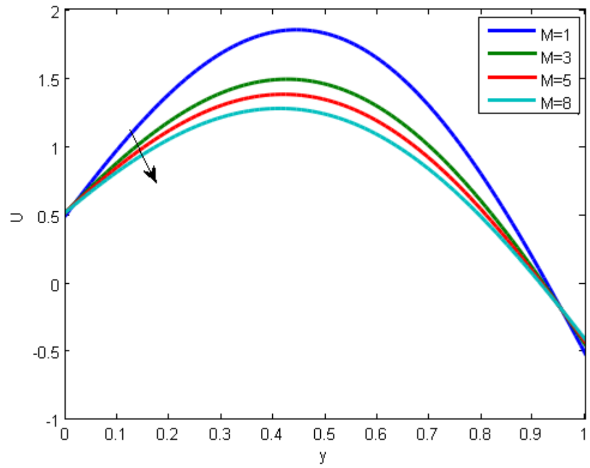

Figure 1.3: Profile of Velocity U, with distinct M values,[D_a=0.1; A=1.0;l=0.1;B=0.0; Pr=0.1;F_0=0.50; R=1; d=0.3]

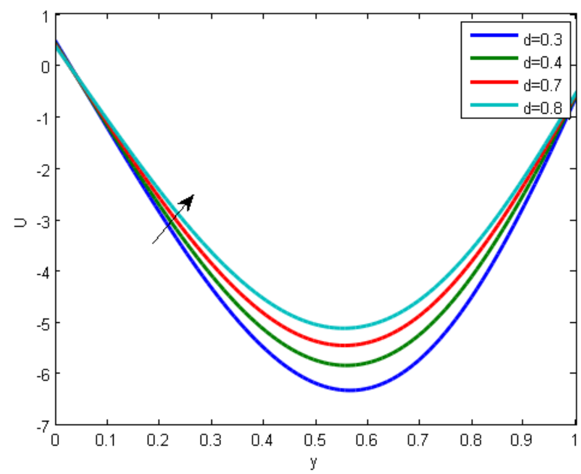

Fig 1.4: Primary VelocityU,with different d values :[Da=0.10;A=1.0; Pr=0.1;B=0;F_0=0.50;M=1.0;R=1]

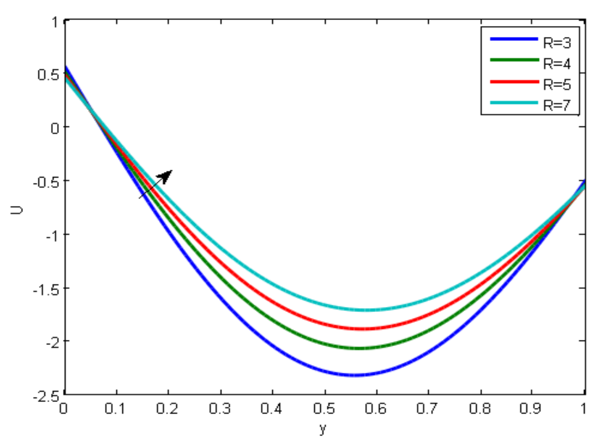

Fig 1.5: Primary velocity U with values of R:[D_a=0.1;Pr=0.1; A=1;l=0.1;B=0;F_0=0.5;M=1]

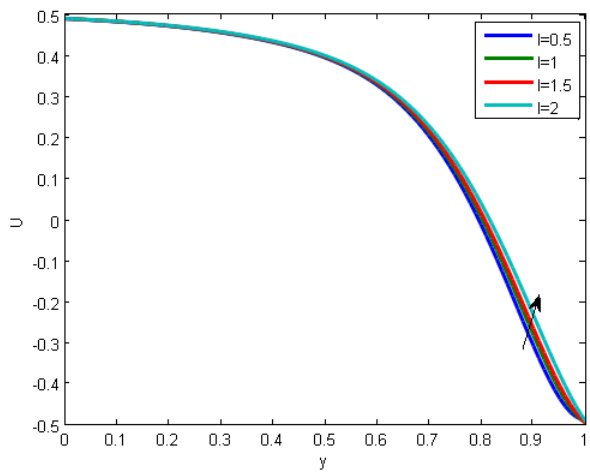

Fig 1.6: Velocity profile 'U' with step up values of l:[Pr=0.1; A=1.0;d=0.3;Da=0.10;B=0.0;F_0=0.50;R=1; M=1.0]

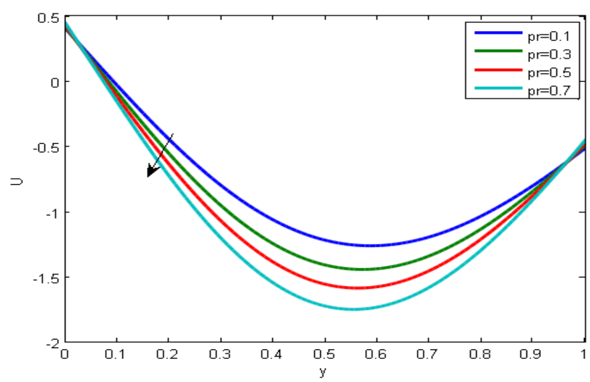

Fig 1.7: Primary velocity U,with different Pr : [M=1;l=0.1;Da=0.1;B=0;F_0=0.5; A=1.0;d=0.3;R=1.0]

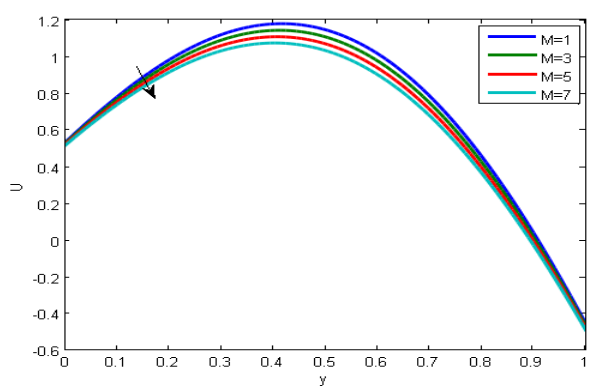

Fig 1.8: Variation of primary velocity U for magnetic parameter M: [D_a=0.10; Pr=0.10;l=0.10;B=1.0;F_0=0.5;A=0;R=1]

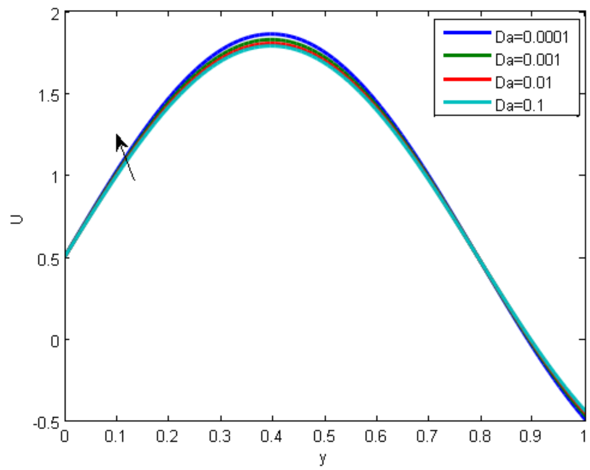

Fig 1.9:Variation of Primary velocity(U), for Da: [l=0.1; d = 0.30;A=0;Pr=0.1;B=1;F_0=0.5;M=1;R=1.0]

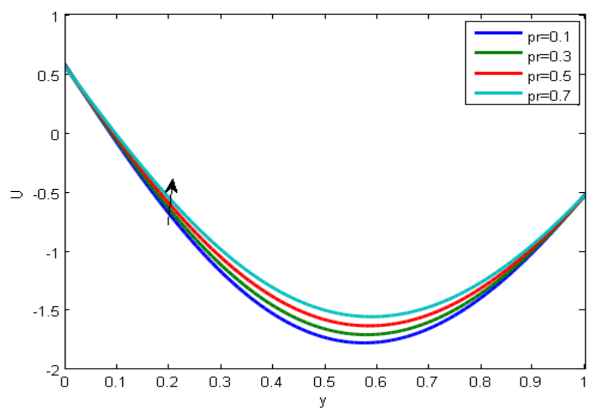

Fig 1.10: Profile of Primary Velocity (U) with distinct values of (Pr): [D_a=0.1;A=0.0; l=0.1;B=1;F_0=0.5;M=1;R=1;d=0.30]

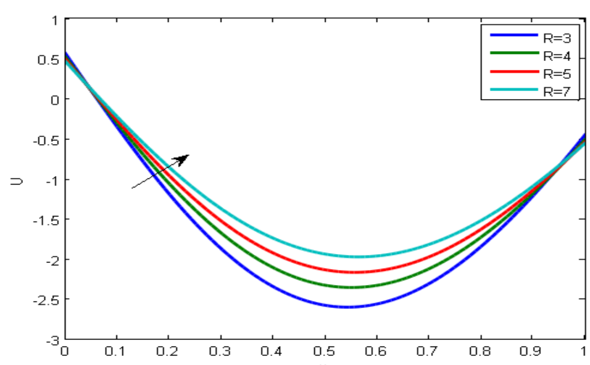

Fig 1.11: Sketch of Primaryvelocity U,with various values of R: [A=0;Da=0.10;l=0.10; B=1.0;F_0=0.50;M=1.0;R=1.0;d=0.30]

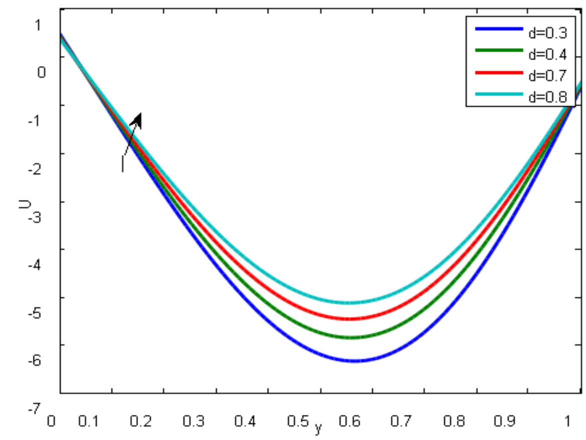

Fig 1.12: Profile of PimaryVelocity distribution ‘U’, for d: [Da=0.1: A=0.0; B=1.0; Pr=0.1; F_0=0.5;M=1.0;R=1.0;D=0.3]

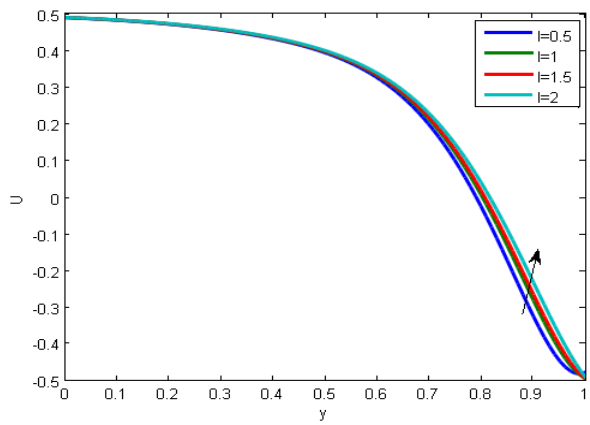

Fig 1.13: Variation of Primary Velocity(U) for l ; [Pr=0.10; A=0.0;M=1.0;Da=00.1, ;R=1.0; B=1.0;F_0=0.5;d=0.3]

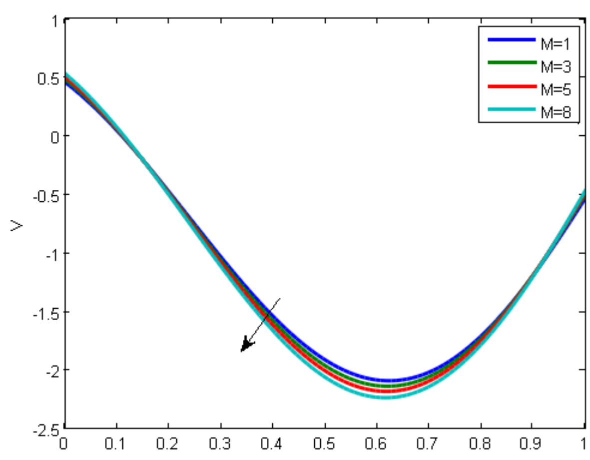

Fig 1.14: Secondary Velocity Distribution V ,with different M; [l=0.1; B=0.0; A=1; d=0.30;Da=0.1;Pr=0.1; F_0=0.50; R=1.0]

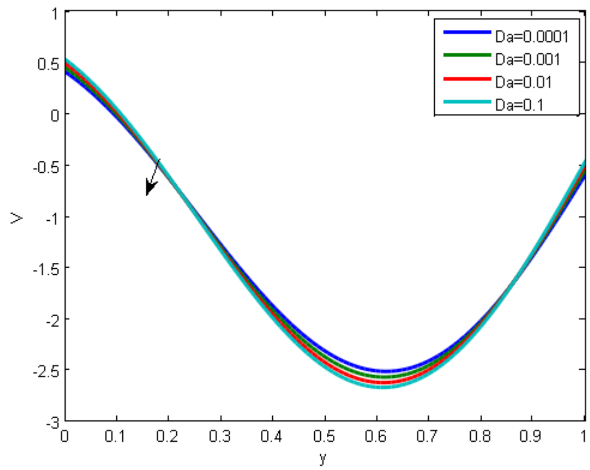

Fig 1.15: Profile of velocity V for Da ; [Pr=0.10, A=1.0;d=0.10;l=0.1;M=1.0;B=0;F_0=0.50;R=1]

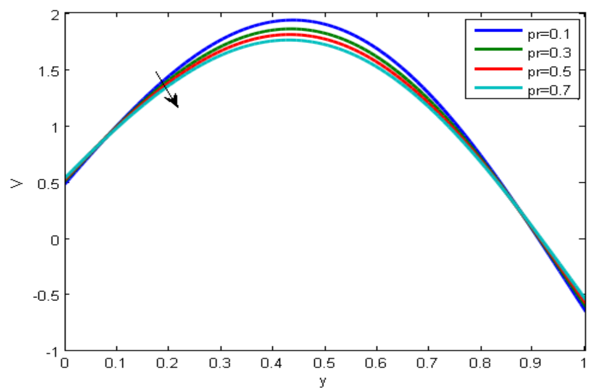

Fig 1.16: Secondary Velocity 'V', with different Pr; [M=1,d=0.3;l=0.1;B=0;A=1.0;F_0=0.5;D_a=0.1;R=1]

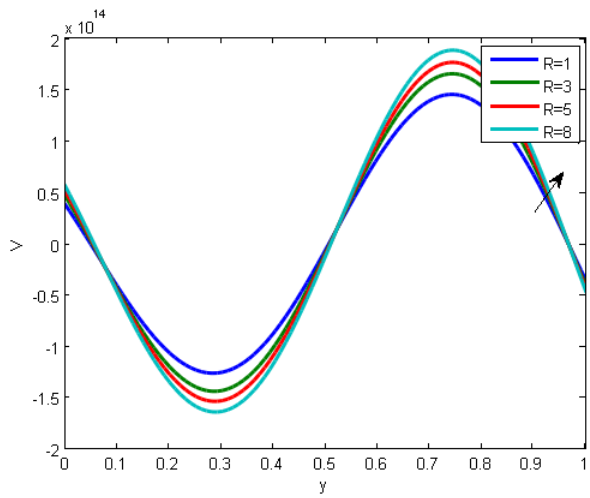

Fig 1.17: Secondary Velocity 'V' for R; [F_0=00.5;Da=0.1;Pr=0.1;M=1,A=1.0;B=0.0;d=0.3;l=0.1]

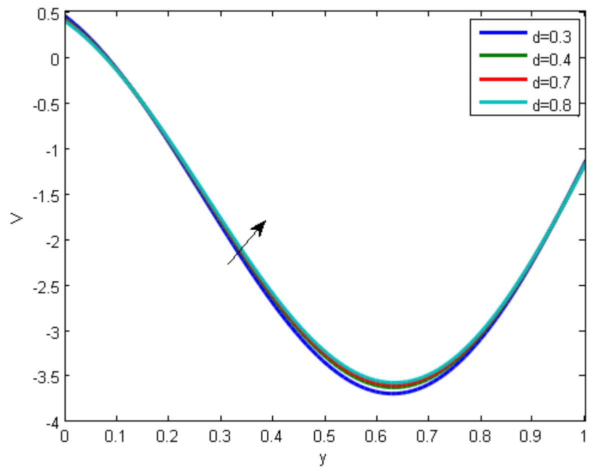

Fig 6.18: Graph of secondary velocity V for d; [M=1.0; B=0.0;l=0.10;Pr=0.10;A=1.0;F_0=0.50;R=1.0]

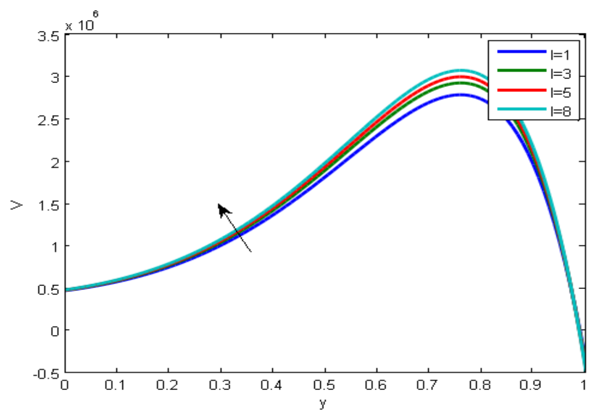

Fig 1.19: Variation of Secondary Velocity(V) for l ; [Pr=0.10; A=1.0;M=1.0;Da=00.1, ;R=1.0; B=0;F_0=0.5;d=0.3]

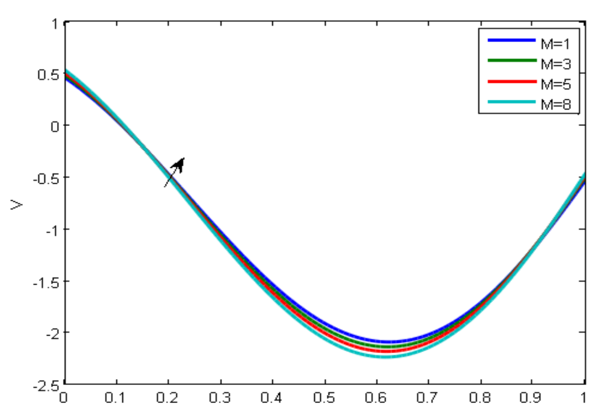

Fig 1.20: Variation of secondary Velocity (V) with distinct magnetic parameter M values; [Da=0.1,A=0.0;l=0.1; Pr=0.1;B=1.0;F_0=0.5;d=0.3;R=1.0]

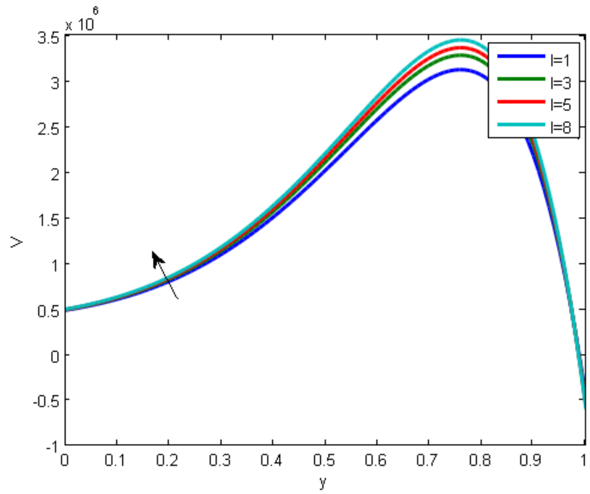

Fig 1.21: Stetch of velocity V for l; [M=1.0;Da=0.10;A=0;Pr=0.1;B=1;F_0=0.50;d=0.30;R=1]

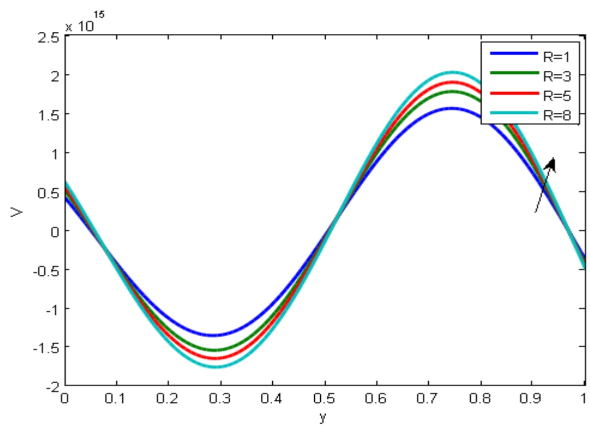

Fig 1.22: Secondary velocity 'V', for R; [M=1.0,A=0.0;B=1.00;F_0=0.50;l=0.1;Pr=0.1;d=0.30;Da=0.1]

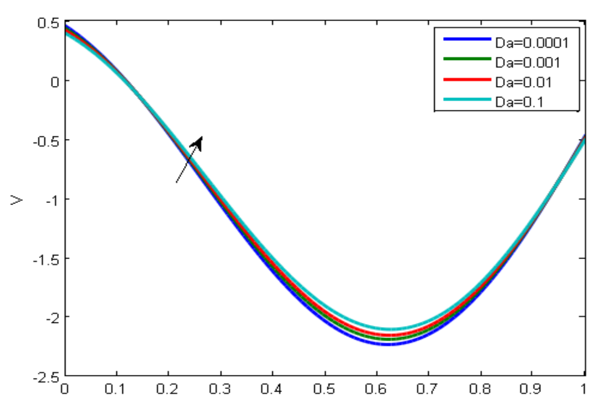

Fig 1.23: Profile of Secondary velocity 'V' for Darcy parameter Da; [M=1.0,A=0.0;B=1.0;F_0=0.50;d=0.30;R=1.0;l=0.1;Pr=0.1]

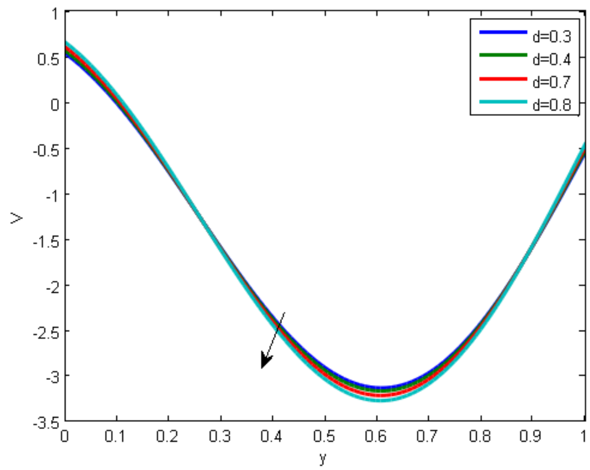

Fig 1.24: Variation of secondary velocity' V ' for d; [M=1.0; B=1.0;F_0=0.50; A=0.0; R=1.00;l=0.10;Pr=0.1;Da=0.10]

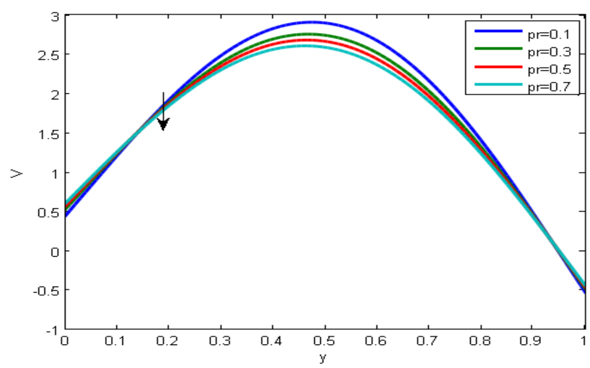

Fig 1.25: Graphof secondary velocity 'V' for Pr; [M=1.0,A=0;B=1;F_0=0.50;d=0.30;R=1.00;l=0.1]

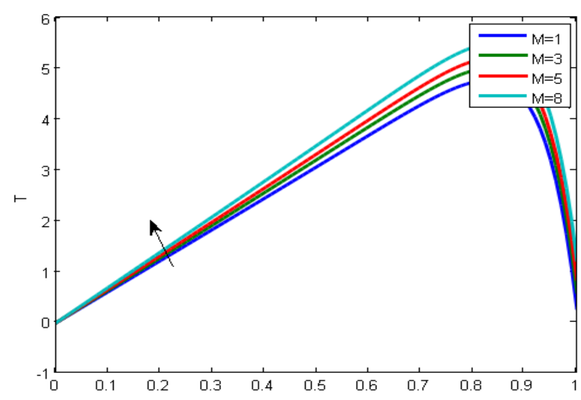

Fig 1.26:Variation of temperature 'T' for M; [R=1.0, l=0.1;A=1.0;B=0.0;F_0=00.5;d=0.3;Da=0.10,Pr=00.1]

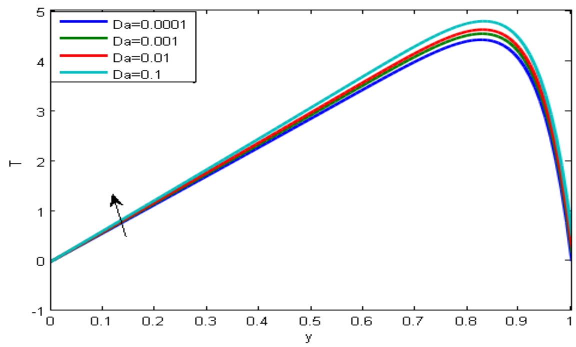

Fig 1.27: Stetch of Temperature distribution 'T' for Darcy parameter; [A=1.0; M=1.00;B=0.0;F_0=0.50;R=1.0;l=0.1;Pr=0.1]

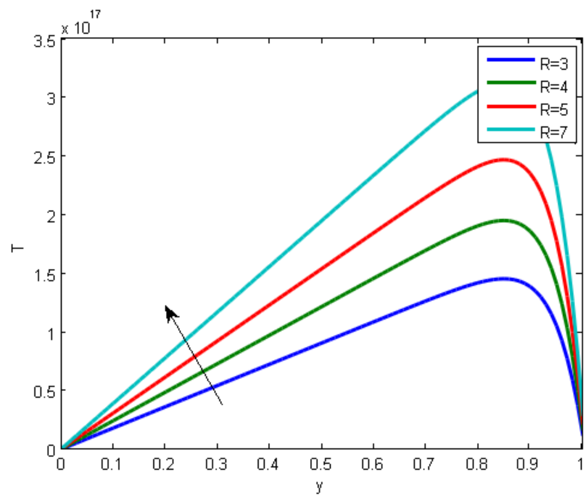

Fig 1.28:Temperature profile T for R; [M=1, A=1.0;B=0.0;F_0=0.5;d=0.30;Da=0.10;l=0.1;Pr=0.10]

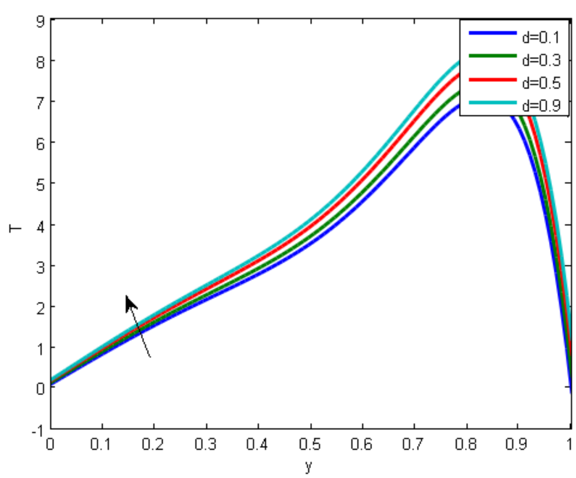

Fig 1.29:Temperature profile T for d; [B=0.0;Da=0.10, A=1.0; Pr=0.10;F_0=0.50;M=1;R=1.0;l=0.10]

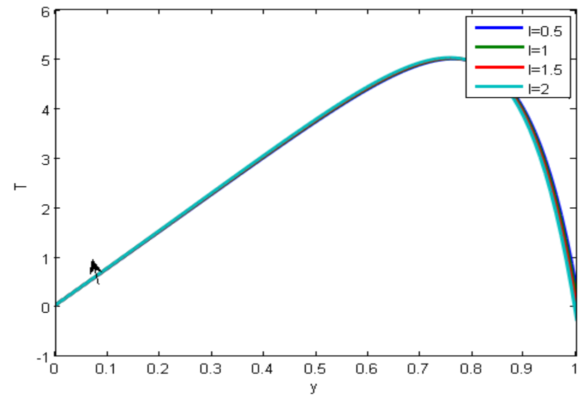

Fig 1.30: Temperature distribution 'T' for l: [A=1.0; M=1.0; B=0.0;F_0=0.50; R=1.0; D_a=0.10;Pr=0.10;d=0.30]

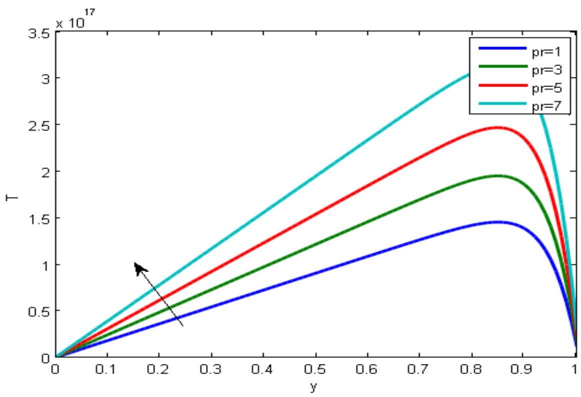

Fig 1.31: Profile of temperature T for Pr; [d=0.30;M=.01;A=1.0;B=0;F_0=0.50;D_a=0.10;l=0.1;R=1.0]

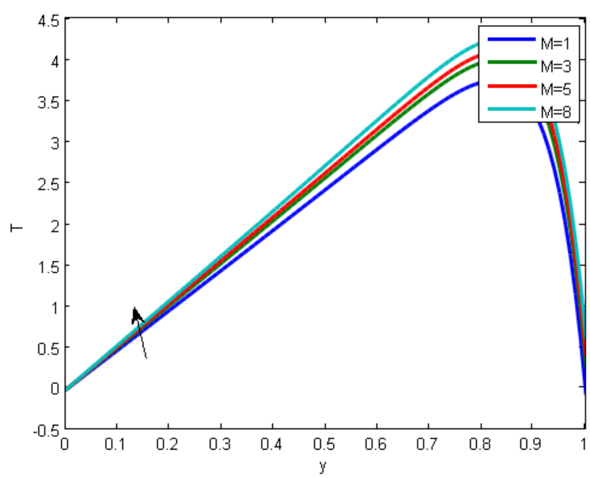

Fig 1.32:Variation of temperature distibution' T 'for M; [A=0.0; d=0.30;B=1.0;F_0=0.50;D_a=0.10;l=0.10;R=1.0]

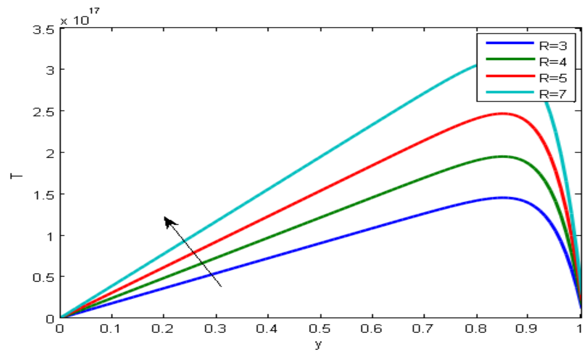

Fig 1.33: Temperature distribution ‘T’ for R: [A=0.0; M=1.0; B=1.0; d=0.30;Pr=0.10; F_0=0.50;l=0.1;Da=0.10]

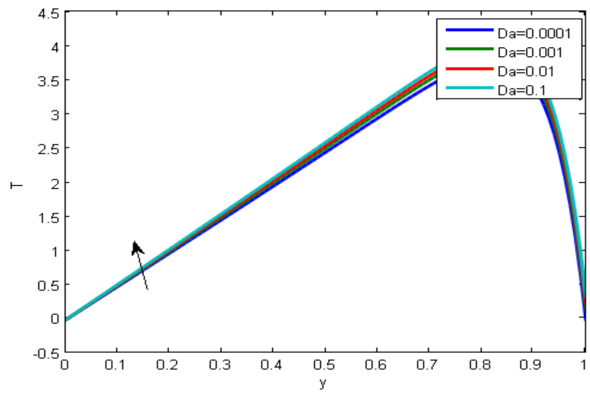

Fig 1.34: Variation of temperature distribution’ T’ for Da: [M=1.0; A=0.0;B=1.0;F_0=0.50;d=0.30;R=1.0;Pr=0.10;l=0.1]

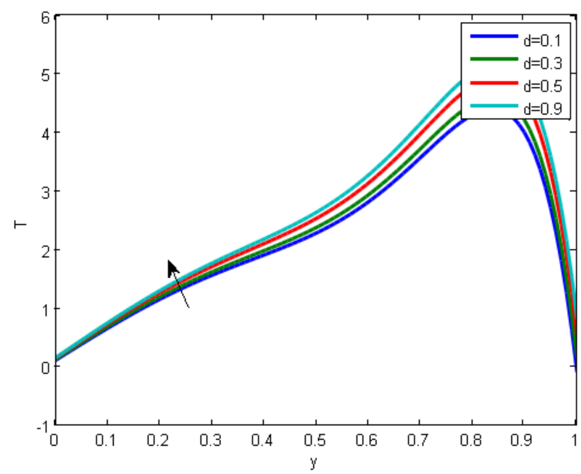

Fig 1.35: Profile of temperature distribution‘T’ for d: [A=0.0; M=1.0;B=1;F_0=0.50; Pr=0.1; Da=00.1;l=0.10;R=1]

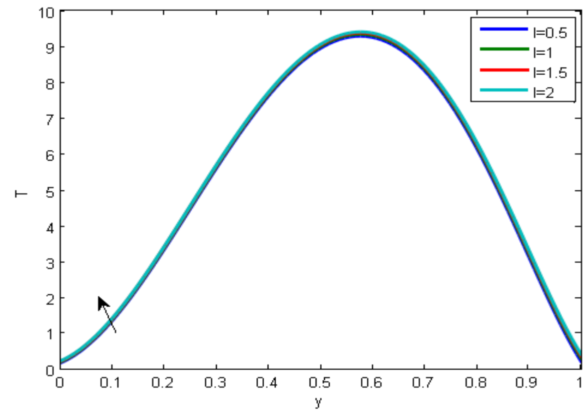

Fig 1.36:Profile of temperature ‘T’ for l: [M=1.0; A=0.0;B=1;F_0=0.5;d=0.30;R=1.0;Pr=0.10;Da=0.1]

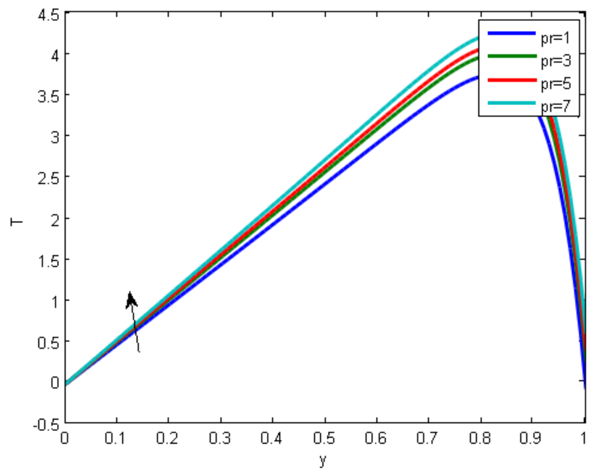

Fig 1.37:Temperature distribution ‘T’ for Pr: [M=1.0, A=0.0;B=1.0;F_0=0.50;l=0.1;d=0.30;R=1.0:Da=0.10]

5. CONCLUDING REMARKS

MHD convective and radiative flow between two infinite plates separated by clear and porous region is considered with hall effect and inclined magnetic field. The obtain differential equation are solved using perturbation technique to acquire solution for primary, secondary and temperature distributions. The graphical conclusion of the afore said distributions narrates that when the plate y=0 is heated the parameter Da, M, Pr are increased, the primary distribution graph degrades but when the physical parameter d, R and λ are upgraded, the graph shows step up flow. The plate y=0 is cooled, the magnetic parameter M and porous parameter λ degrades the primary flow whereas on increasing Da, Pr, R, d values, the primary flow enhances. Considering the secondary flow, when y=0 is heated(A=1,B=0) , increasing parameters Pr, R, d, λ the secondary flow gets elevated. On the other hand when M and Da are increased the graph proliferates. The secondary velocity flow is examined when the plate y=0 is cooled (A=0, B=1) for increasing the values of λ, M, R, Da the graph gets elevated and for parameters d and Pr the graph shows step down flow. The temperature distribution graph is analyzed for different temperature cases and it is concluded that when the plates are heated or cooled the temperature distribution graph proliferates by increasing all the parameters involved in the present flow.

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