IMPACT OF MAGNETIC FIELD ON JEFFERY FLUID FLOW WITH BAFFLE

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Abstract

Impact Of magnetic field on jeffery fluid flow with baffle have been studied. The governing equations were simplified analytically and numerically by using boundary and interface condition at distinct baffle position .Solution for velocity ,temperature have been obtained for Jeffery, viscous and magnetic parameter in a vertical channel ,results are displayed graphically for numerous important non-dimensional parameter and exposed graphically .we found that the expression for increase in GR_T,GR_C which leads to increases velocity as well as temperature and decreases for the porous ,viscosity ,magnetic parameter and chemical reaction parameter.

Keywords: Baffle; Jeffrey fluid; MHD; Chemical Reaction; porous material; perturbation technique.

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1. Introduction

The analysis of the magnetohydrodynamic (MHD) such as fluid include plasma, liquid metals and salt water or electrolytes. The word magneto is magnetic field and hydro is a liquid and dynamic is significance movement. Main conception of MHD is that magnetic field can make currents in a moving conductive fluid due to this creates forces on the fluid and also changes the magnetic field. The Navier-Stokes equations is combination of MHD and differential equation have to solved by analytical or numerically.

Most significant important of a baffle is to use the mixing of a vessel and it is decreases in time reaction and cost operating along these increases in conversion as well as efficiency. Baffles plate is also useful for promote an equal distribution of materials and properties vertically in a vessel, this results an important and visible when the fluid has a high Reynolds Number and also when there is a low viscosity, and it used to enlarge the thermal transfer coefficient to increase the shell side by generating turbulence in the shell side fluid by adjusting the parallel flow pattern, it also prevents the fluid force or movement.

Jeffrey fluid which is consider as one of the non-Newtonianfluids, it capable of narrate the properties of stress relaxation in which the viscous fluid cannot describe. Many literature surveys have essayed the fluid flow problems in Jeffrey fluid, MHD, and electrically conducting flow likes, Prathap Kumar et. al [1]studied about free convective flow of electrically conducting viscous immiscible fluid flow in a vertical channel in the presence of first – order chemical reaction. SnthoshNallapu, et. al[2] analysed Jeffrey fluid flow through a narrowtubes in the presence of a magnetic field. Rekha Bali, Usha Awasthi[3] studied the mathematical model of blood flow in small blood vessel in the presence of magnetic field. M. Krishna Murthy[4] examined the MHD Couette flow of jeffrey fluid in a porous channel with heat source and chemical reaction. Nirmala[5] A study of Jeffery fluid flow in a vertical channel with wall slip and hall current . Chamkhaand Veera Krishna studies the effects of thermo-diffusion, chemical reaction, ion slip, and Hall on MHD rotational flow of a micropolar fluid across an infinite vertical porous surface [6]. Veera Krishna et al. [7] describe investigation solutions for unsteady MHD (magnetohydrodynamic) flows with thermal radiation over a vertically oscillating plate placed in a Darci porous medium with characteristics of heat and mass transfer of Boussinesq fluid, an incompressible, viscous, and electrically conductive. Mass and heat transfer in free convective flow micropolar fluids with a porous surface, an angled magnetic field, and Hall effects" by Anand [8] gives the properties of mass and heat transfer on a micropolar fluid's free convective flow over an infinite vertical porous plate while a magnetic field is inclined at an angle. Chamkha and Veera Krishna [9] are mentioned work on a free convective flow of nano-fluids (TiO2 and Ag) around a semi-infinite permeable moving plate with a continuous heat source revealed the properties of radioactive absorption, diffusion-thermo, ion slip and Hall. Similar work done by ref. 10 to 22. Many research work on mixed convection and nanoparticles and it has a wield application and important Rollin research by using numerically solved general case related to viscous dissipation.[19,20].

By reading the aforementioned literature, I was motivated to do research on the result of synthetic response with magneto convection on Jeffery fluid flow in presence of baffle while maintaining various wall temperatures and concentrations. By using the regular perturbation approach, expressions for concentration, temperature, and velocity were resulting analytically and the outcome is displayed graphically.

Mathematical Formulation

Analyze the fluid motion in a vertical channel filled with Jeffrey fluid and MHD in region-I and II, correspondingly in a two-dimensional (2D) fully formed free convection flow. The up-word force taken vertically parallel to x- axis, and it is and normal to it y-axis as shown in Fig.1.1.The passage is divided by a thin perfectly conducting planar partition and each region has its own pressure gradient, velocity, temperature and concentration will be separate in each region.

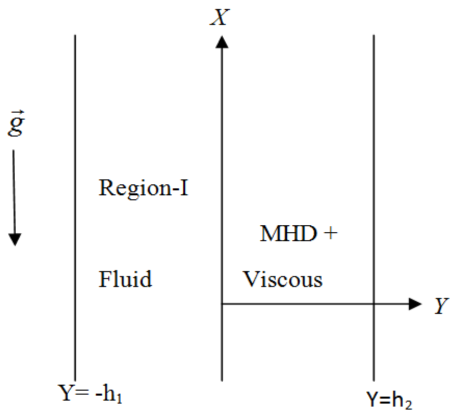

Fig.1.1.1Physical Modal

The governing equations for fluid flow, heat, and concentration are derived under the aforementioned conditions:

Region-I

$$\rho g\beta_T(T_1-T_{w2})+\rho g\beta_c(c_1-\overline{c_2})+\frac{\mu_1}{(1+\lambda)}\frac{d^2u_1}{dy^2}-\frac{dp}{dx}=0$$

$$\frac{d^2T_1}{dY^2}=-\frac{\upsilon_1}{\alpha_1 c_p}\left(\frac{dU_1}{dY}\right)^2$$

$$D_1\frac{d^2C_1}{dY^2}-k_1c_1=0 \tag{1}$$

Region-II

$$\rho g\beta_T(T_2-T_{w2})+\rho g\beta_c(c_2-\overline{c_2})+\mu_2\frac{d^2u_2}{dy^2}-\frac{dp}{dX}-\sigma B_0^2u_2B_0=0$$

$$\alpha_2\frac{d^2T_2}{dY^2}+\frac{\upsilon_2}{c_p}\left(\frac{dU_2}{dY}\right)^2+\frac{\sigma}{\rho_2 c_p}(B_0u_2)^2=0$$

$$D_2\frac{d^2C_2}{dY^2}-K_2C_2=0 \tag{2}$$

The above interface as well as boundary conditions of velocity, temperature, and concentrations is

$$\text{“}U_1(-h)=0,\ T_1(-h)=T_{W1}, C_1(-h)=\overline{C_1}$$

$$U_2(h)=0,\ T_2\ (h)=T_{W2}$$

$$U_1(h^*)=U_2(h^*)=0,\ T_1(h^*)=T_2(h^*),\quad \frac{dT_1(h^*)}{dY}=\frac{dT_2(h^*)}{dY}$$

$$\phi_1(-h)=1,\phi_2(h)=0,\frac{d\phi_1}{dY}(y^*)=\frac{d\phi_2}{dY}(y^*)\text{”} \tag{3}$$

We now introduce the following non-dimensional transformations

$$u_i=\frac{U_i}{\overline{\overline{U_1}}},\quad y_i=\frac{Y_i}{h_i},\quad \theta_1=\frac{T_1-T_{w2}}{T_{w1}-T_{w2}},\quad \theta_2=\frac{T_2-T_{w2}}{T_{w1}-T_{w2}},\quad Gr=\frac{g\beta_{T1}h_1^3(T_{w1}-T_{w2})}{\upsilon_1^2},\quad \mathrm{Re}=\frac{\overline{U_1}h_1}{\upsilon_1},$$

$$Gr=\frac{g\beta_{c1}h_1^3(C_{w1}-C_{w2})}{\upsilon_1^2},\quad p=\frac{h_1^2}{\mu_1\overline{\overline{U_1}}}\frac{dp}{dX},\ \phi_1=\frac{C_1-\overline{C_1}}{\overline{\overline{C_1}}-\overline{\overline{C_2}}},\phi_2=\frac{C_2-\overline{C_2}}{\overline{\overline{C_1}}-\overline{\overline{C_2}}},\ B_r=\frac{\mu_1\overline{u_1}^2}{k\Delta T},$$

$$M^2=\frac{\sigma B_0^2h_1^2}{\mu_1}. \tag{4}$$

Substituting in the non-dimensional variables into eqs. (1) to (2) we get

Region-I

$$\frac{d^2u_1}{dy^2}+(1+\lambda)G_1\theta_1+(1+\lambda)G_2\phi_1-(1+\lambda)p=0$$

$$\frac{d^2\theta_1}{dy^2}=-B_r\left(\frac{du_1}{dy}\right)^2$$

$$\frac{d^2\phi_1}{dy^2}-\alpha^2{}_1\phi_1=0 \tag{5}$$

Region-II

$$\frac{d^2u_2}{dy^2}=a_1\theta_2+a_2\phi_2+a_3+\sigma^2u_2$$

$$\frac{d^2\theta_2}{dy^2}+Br\left[\frac{k}{m}\left(\frac{du_2}{dy}\right)^2+M^2h^2k\sigma u_2^2\right]=0$$

$$\frac{d^2\phi_2}{dy^2}-\alpha^2{}_2\phi_2=0 \tag{6}$$

where

$$GR_T=G_1,\ GR_C=G_2,\ h,\quad m=\frac{\mu_1}{\mu_2},\quad b_t=\frac{\beta_{T2}}{\beta_{T1}},\ b_c=\frac{\beta_{C2}}{\beta_{C1}}\ n=\left(\frac{\rho_2}{\rho_1}\right),D=\left(\frac{D_2}{D_1}\right),\alpha=\left(\frac{\alpha_2}{\alpha_1}\right).$$

The non-dimensional equation for boundary and interface state becomes,

$$u_{10}(-1)=0\ ,\ u_{20}(1)=0,\ \theta_{10}(-1)=1\ ,\ \theta_{20}(1)=0\ ,u_{11}(-1)=0\ ,u_{21}(1)=0\ ,u_{10}(y^*)=0$$
$$u_{20}(y^*)=0\ ,\ \theta_{10}(y^*)=\theta_{20}(y^*),\theta_{11}(y^*)=\theta_{21}(y^*),\ \phi_1(-1)=1\ ,\ \phi_2(1)=0\ ,$$
$$\frac{d\theta_{10}}{dy}(y^*)=\frac{d\theta_{20}}{dy}(y^*)\ ,\frac{d\theta_{11}}{dy}(y^*)=\frac{d\theta_{21}}{dy}(y^*)\ ,\ u_{11}(y^*)=0,\ u_{21}(y^*)=0,\ \theta_{11}(-1)=0,$$
$$\theta_{21}(1)=0,\ \phi_1(y^*)=\phi_2(y^*)\ ,\ \frac{d\phi_1}{dy}(y^*)=\frac{d\phi_2}{dy}(y^*). \tag{7}$$

Method of Solution

The equations from eqn. (5 to 6) are work by analytically as well as numerically operating the suitable boundary and interface conditions (7) and obtained solutions are shown below

Perturbation Method:

By taking regular perturbations technique the solutions be obtained, assuming that the brinkman number is a small perturbation parameter, and comparing similar powers of epsilon with powers of zero and we find a first-sequence ordinary equation, and ignore the higher power we get the solution, and the results are discussed graphically.

$$\varepsilon=Br \tag{8}$$

The form of the solution is assumed to be,

"$$u(y)=u_0(y)+\varepsilon u_1(y)+\varepsilon^2u_2(y)+....=\sum_{n=0}^{\infty}\varepsilon^nu_n(y) \tag{9}$$

$$\theta(y)=\theta_0(y)+\varepsilon\theta_1(y)+\varepsilon^2\theta_2(y)+....=\sum_{n=0}^{\infty}\varepsilon^nu_n(y) \tag{10}$$

Region-I Zeroth-Order Equations

$$\theta_{10}=c_1y+c_2$$

$$u_{10} = A_2 + A_1 y + q_1 y^2 + q_2 y^3 + q_3 Cosh[\alpha_1 y] + q_4 Sinh[\alpha_1 y]$$

$$\phi_1 = b_1 Cosh[\alpha_1 y] + b_2 Sinh[\alpha_1 y] \quad (11)$$

Region-II

$$\theta_{20} = c_3 y + c_4$$

$$\phi_2 = b_3 Cosh[\alpha_2 y] + b_4 Sinh[\alpha_2 y]$$

$$u_{20} = A_3 Cosh[\sigma y] + A_4 Sin[\sigma y] + q_5 + q_6 y + q_7 Cosh[\alpha_2 y] + q_8 Sinh[\alpha_2 y] \quad (12)$$

First – Order Equations

Region-I

$$\theta_{11} = A_6 + A_5 y + y^2 q_9 + y^3 q_{10} + y^4 q_{11} + y^5 q_{12} + y^6 q_{13} + q_{14} Cosh[\alpha_1 y] + q_{15} y Cosh[\alpha_1 y] + q_{16} y^2 Cosh[\alpha_1 y] + q_{17} Cosh[2\alpha_1 y] + q_{18} Sinh[\alpha_1 y] + q_{19} y Sinh[\alpha_1 y] + q_{20} y^2 Sinh[\alpha_1 y] + q_{21} Sinh[2\alpha_1 y]$$

$$u_{11} = B_2 + B_1 y + q_{22} y^2 + q_{23} y^3 + q_{24} y^4 + y^5 q_{25} + y^6 q_{26} + y^7 q_{27} + y^8 q_{28} + q_{29} Cosh[\alpha_1 y] + q_{30} y Cosh[\alpha_1 y] + q_{31} y^2 Cosh[\alpha_1 y] + q_{32} Cosh[2\alpha_1 y] + q_{33} y^2 Cosh[2\alpha_1 y] + q_{34} Sinh[\alpha_1 y] + q_{35} y Sinh[\alpha_1 y] + q_{36} y^2 Sinh[\alpha_1 y] + q_{37} y^3 Sinh[2\alpha_1 y] + q_{83} y Sinh[2\alpha_1 y] \quad (13)$$

Region-II

$$\theta_{21} = A_8 + A_7 y + q_{38} y^2 + q_{39} y^3 + q_{40} y^4 + q_{41} Cosh[\alpha_2 y] + q_{42} y Cosh[\alpha_2 y] + q_{43} Cosh[2\alpha_2 y] + q_{44} Cosh[\sigma y] + q_{45} y Cosh[\sigma y] + q_{46} Cosh[2\sigma y] + q_{47} Cosh[(\alpha_2 - \sigma) y] + q_{48} Cosh[y\alpha_2] Cosh[\sigma y] + q_{49} Cosh[(\alpha_2 + \sigma) y] + q_{50} Sinh[\alpha_2 y] + q_{51} y Sinh[\alpha_2 y] + q_{52} Sinh[\sigma y] + q_{53} y Sinh[\sigma y] + q_{54} Sinh[2\alpha_2 y] + q_{55} Sinh[\sigma y] + q_{56} Cosh[\sigma y] Sinh[\alpha_2 y] + q_{57} Sinh[(\alpha_2 - \sigma) y] + q_{58} Sinh \frac{[\sigma y]}{2} Cosh \frac{[\sigma y]}{2} + q_{59} Cosh[\alpha_2 y] Sinh[\sigma y] + q_{60} Sinh[\alpha_2 y] Sinh[\sigma y] + q_{61} Sinhh[(\alpha_2 + \sigma) y]$$

$$u_{21} = B_3 Cosh[\sigma y] + B_4 Sinh[\sigma y] + q_{62} + q_{63} y + q_{64} y^2 + q_{65} y^3 + q_{66} y^4 + q_{67} Cosh[\alpha_2 y] + q_{68} Sinh[\alpha_2 y] + q_{69} Cosh[2\alpha_2 y] + q_{70} Sinh[2\alpha_2 y] + q_{71} Cosh[2(\sigma) y] + q_{72} Sinh[2(\sigma) y] + q_{73} y Cosh[\sigma y] + q_{74} y \sinh[\sigma y] + q_{75} y \cosh[\alpha_2 y] + q_{76} y Sinh[\alpha_2 y] + q_{77} Cosh[(\alpha_2 + \sigma) y] + q_{78} Cosh[(\alpha_2 - \sigma) y] + q_{79} Sinh[(\alpha_2 + \sigma) y] + q_{80} Sinh[(\alpha_2 - \sigma) y] + q_{81} Sinh[\sigma y] y^2 + q_{82} Cosh[\sigma y] y^2. \quad (14)"$$

2. Results & Discussions

This research explores
Impact Of magnetic field on jeffery fluid flow with baffle in a vertical channel. The transfer of heat flow is studied as an influence of control parameters are studied.The proportion of thermal Grashof number to Reynold number GR_T,Mass Grashof number to Reynold number GR_C ,Pressure gradient and perturbation variable is stable as $1, 1, -0.5$ and 0.1 graphs separately excepts for the varying one. Profiles showing velocity and temperature at a different values of the Thermal Grasshof number GR_T , are seen in all three baffle positions in figures 1 (a-c), and 2(a-c) $i.e[\, y^* = (-0.2, 0, 0.2)]$. Increases in bouncing force, measured by the Thermal Grashof number, cause both temperature and velocity to rise in proportion. Similar profiles showing for velocity and temperature at a different values of the Mass Grasshof number GR_C ,in all three baffle positions as shown in figures 3 (a-c), and 4 (a-c) $i.e[\, y^* = (-0.2, 0, 0.2)$ .This is due to the proportion of concentration of up word force to viscous force, it implies increase in concentration buoyancy force which increases the flow field.Hence result enhancement in velocity and temperature in both the region. As we seen in Figures 5(a–c), and 6(a–c), the velocity as well as temperature of fluid flow drop in both regions as the porous parameter increases. This is because of the porosity properties of the material. Therefore, decreases in velocity and temperature The velocity and temperature profile for Jeffery variable are shown in figures7

(a-c) and 8 (a-c) with the increase of a Jeffrey parameter we can see that in fluid flow improves its flow behavior hence the velocity increase in regions-I. This is because due to the presence of non-Newtonian fluid property in region-I, hence enhances the velocity and temperature is decreases for both the region. Figures 9 (a-c) and 10 (a-c) show the velocity and temperature curves for the viscosity parameter, respectively. The velocity and temperature decreases both the region. This is due to the viscosity of fluid flow is enhances than that of the fluid, Resulting drop in velocity and temperature both the region. Figures 11 (a-c) and 12 (a-c) show the velocity and temperature curves for the effect of magnetic field respectively. The velocity and temperature reduces to both region. Due to its Darcey effect. Figures 13 (a-c) ,14 (a-c) and 15 (a-c) show the velocity, heat and concentration curves for the combinations of chemical response variable, respectively. The velocity, temperature and also concentration decreases in both the region. Molecular behavior in fluid flow is lowered when the chemical reaction parameter rises, since these results in a rise in the number of dissolved molecules and a corresponding drop in the flow rate behavior. Figures 16 (a-c) and 17 (a-c) show the velocity and temperature profile for the thermal conductivity parameter, respectively. Increases k increases the viscous dissipation, which increases the velocity and also enhanced the temperature. Hence result enhances the velocity and temperature in both the region. Figures 18 (a-c) and 19 (a-c) show the velocity and temperature profile for the width ratio, respectively. The velocity and temperature increases in the both the region, this is because of the nonconducting fluid is more width as contrast to width of conducting fluid, therefore increasing in flow fluid respectively .

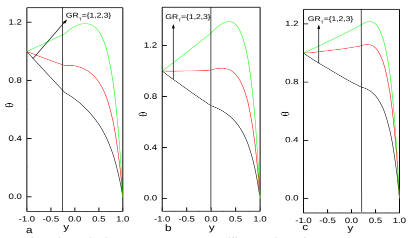

Fig2 Dimensionless Temperature For Diffrent Value Of GR_T

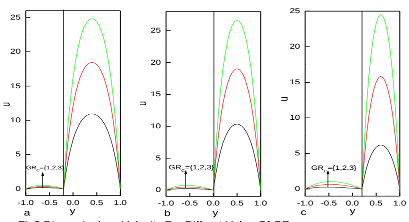

Fig3 Dimensionless Velocity For Diffrent Value Of GR_C

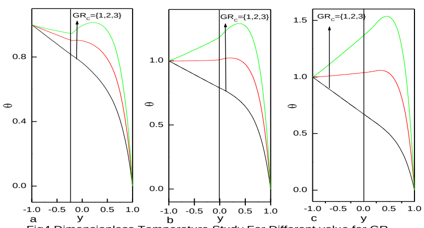

Fig4 Dimensionless Temperature Study For Different value for GR_C

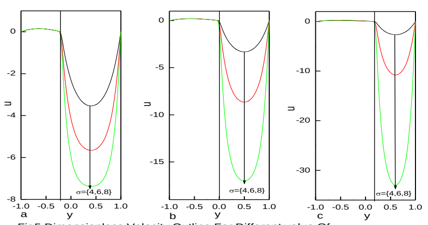

Fig5 Dimensionless Velocity Outline For Different value Of σ

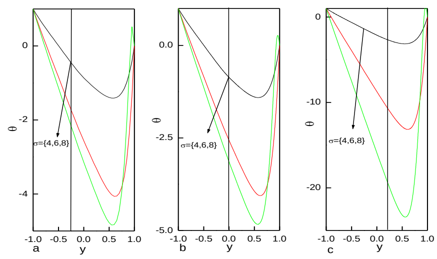

Fig6 Dimensionlessn Temperature Outline For Distinct Value Of σ

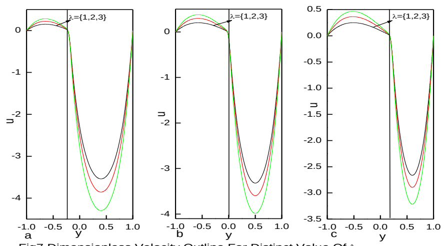

Fig7 Dimensionless Velocity Outline For Distinct Value Of λ

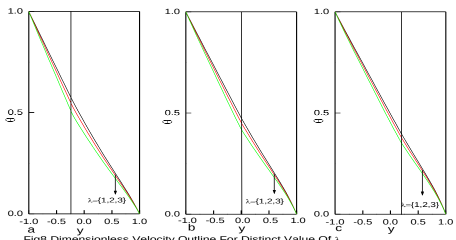

Fig8 Dimensionless Velocity Outline For Distinct Value Of λ

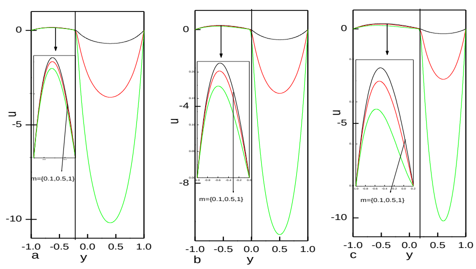

Fig9 Dimensionless Velocity Outline For Distinct Value Of Viscosity Ratio (m)

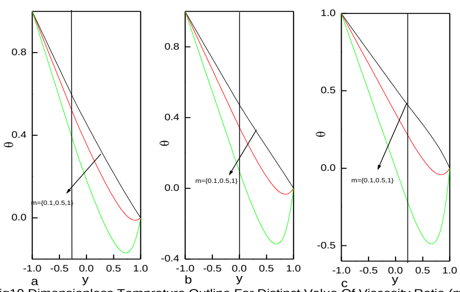

Fig10 Dimensionless Temprature Outline For Distinct Value Of Viscosity Ratio (m)

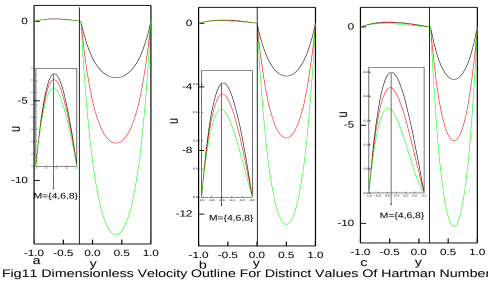

Fig11 Dimensionless Velocity Outline For Distinct Values Of Hartman Number M

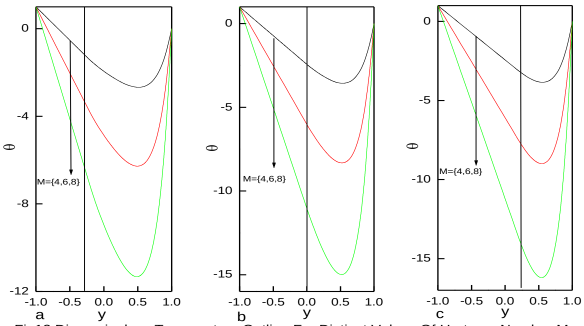

Fig12 Dimensionless Temperature Outline For Distinct Values Of Hartman Number M

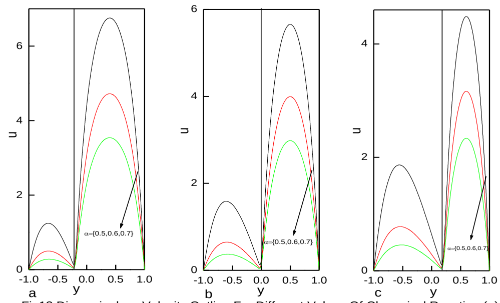

Fig13 Dimensionless Velocity Outline For Different Values Of Cheemical Reaction (α)

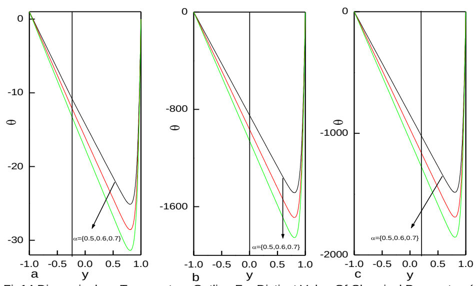

Fig14 Dimensionless Temperature Outline For Distinct Value Of Chemical Parameter (α)

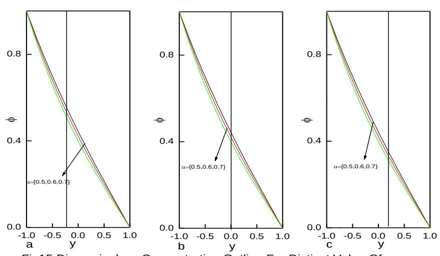

Fig15 Dimensionless Concentration Outline For Distinct Value Of α

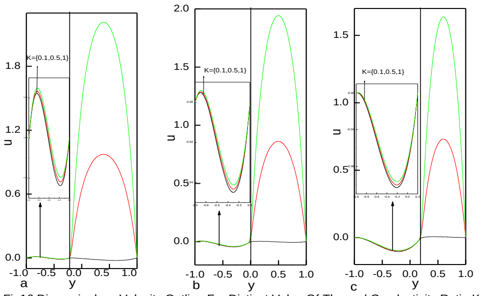

Fig16 Dimensionless Velocity Outline For Distinct Value Of Thermal Conductivity Ratio K

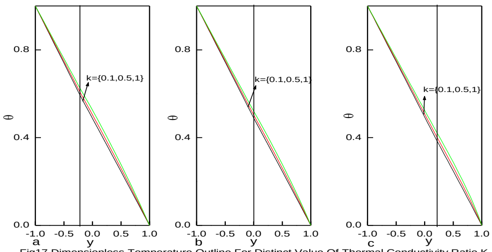

Fig17 Dimensionless Temperature Outline For Distinct Value Of Thermal Conductivity Ratio K

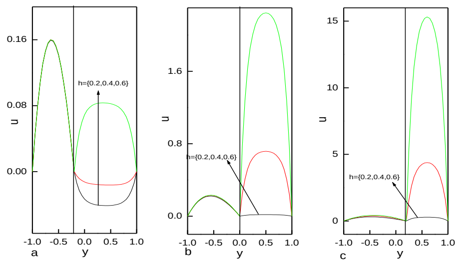

FIG18 Velocity Profile For Different Value Of h

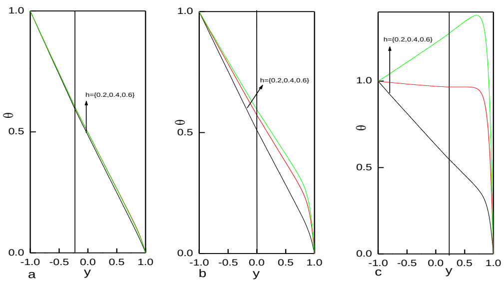

Fig19 Dimensionless Temperature Outline For Distinct Value Of Width Ratio h

3. Conclusion

Impact Of magnetic field on jeffery fluid flow with baffle has been studied in a vertical channel the important results are discussed below.

1] With the increases of GR_T, GR_c, Jeffrey parameter, thermal conductivity and width ratio we can observe the enhancement of fluid flow behaviour for velocity profile and temperature profile for all diverse baffle positions due to the increase in buoyancy force.

2] The increases in porous parameter there is suppression in fluid flow for velocity, temperature fields this is due to the porosity.

3] With increase in value of α its enhancement in the salute particles as a result it decreases the fluid flow for velocity, temperature and concentration.

4] With the increase in thermal conductivity and width ratio increases the velocity and temperature.

5] The velocity and temperature for the Hartman number decreases because of Darcy effect.

6] This paper is hold good with Prathap Kumar[1], Free Convective Flow of Electrically Conducting and Viscous Immiscible Fluid Flow in a Vertical Channel in the Presence of First-Order Chemical Reaction in absence of baffle.

Conflict of Interest: Authors are not having any conflict of interest with any reviewers.

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