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Influence of Radiation and Soret on MHD Free Convective Flow through an Oscillatory Porous Medium with Constant Suction Velocity in Presence of Hall and Ion-Slip Current

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Abstract

In the present examination, consider an Influence of radiation and soret on MHD free convective flow through an oscillatory porous medium with constant suction velocity in presence of hall and ion-slip current. The modelling equations are transformed in to dimensionless equations and then solved analytically through multiple regular perturbation law. Computations were performed graphically to analyze the behaviour of fluid velocity, temperature and Concentration on the vertical plate with the difference of emerging physical parameters. This study reflects that the incremental values of hall and ion-slip current lead to rise in velocity. However, velocity and concentration declined with the incremental values of radiative conduction parameter.

Keywords: Hall and Ion-slip parameter, MHD, perturbation method, Soret**,** Chemical reaction, Radiation.

1. Introduction:

Unsteady MHD has number of utilizations in designing, agribusiness and oil ventures. The issue of characteristic convection under the impact of attractive field has likewise applications in geophysics and astronomy, MHD generator, plasma examines, atomic reactors, geothermal extractors and limit layer control in the field of air transportation, MHD pumps, MHD power generator, polymer innovation, aerodynamic heating and accelerators and quickening agents, in cooling of electronic gadgets like mobiles, PCs and so on and sunlight based boards and decontamination of unrefined petroleum in oil ventures and so forth. Meteorologists can utilize this examination to comprehend elements of climatic changes and thunder storms. Jithender Reddy *et al* [1] have considered unsteady magneto hydrodynamic natural convective heat and mass transfer of a viscous, rotating fluid, electrically conducting and incompressible fluid flow past an impulsively moving vertical plate embedded in porous medium in the presence of ramped temperature, thermal diffusion and diffusion thermo, thermal radiation and hall current. Delowar *et al.* [2] analyzed Unsteady Magneto Hydrodynamic free convection and mass transfer flow through a vertical oscillatory porous plate with hall, ion-slip currents and heat source in a rotating system. MHD unsteady free convection fluid flow past an indiscreetly moving vertical plate with Newtonian surface heating inserted in a permeable medium considering the effect of Hall current. Balvinder Pal Garg *et al.* [3] analyzed Hall Effect on the MHD convective flow of a viscoelastic fluid through a porous medium filled in an oscillatory vertical channel. Nisat Nowroz *et al.* [4] numerical treatment of Magneto Hydrodynamic on unsteady fluid flow past an infinite rotating vertical permeable plate with heat transfer considering Hall current has been made. Odero *et al* [5] have considered the motion of unsteady flow of a viscous on Magneto Hydrodynamic fluid flowing past an in- finite porous plate subjected to convective surface boundary conditions. Xiaohong Su [6]. Studied mixed convective flow of a Cu-water nanofluid over a vertical convectively heated plate on unsteady Magneto Hydrodynamic. The effect of Hall and ion-slip current have likewise been contemplated. RamReddy *et al* [7] have investigated influence of Ion-slip, Hall current and Soret on the steady, mixed convective heat and mass transfer on fully developed flow in an electrically conducting Newtonian fluid between vertical parallel plates. Bilal *et al* [8] Magneto-Microplar nanofluid flow with suction or injection in a porous medium over a stretching sheet for the heat and mass transfer is analyzed numerically. Both Hall and ion-slip effects are considered along with variable thermal diffusivity. Sarma *et al* [9]. Investigated the effects of Soret, rotation, Hall current and electrically conducting on an unsteady MHD free convection heat and mass transfer flow of an incompressible, viscous fluid past an infinite vertical plate installed in a porous medium.

The effects of radiation on Magneto Hydrodynamic flow and heat transfer issues have turned out to be modernly more critical. A few engineering forms occur at high temperatures and henceforth the information of thermal radiation heat transfer is fundamental for planning of legitimate supplies, for example, gas turbines, atomic power plants and diverse impetus gadgets for air ship, rockets and satellites. At the point when radiative heat move happens in the electrically conducting fluid, it is ionized because of the high working temperature. In perspective of these, numerous analysts have made commitments to the investigation of fluid flow with thermal radiation. Gireesha *et al* [10]. Analyzed the effect of radiation on unsteady laminar flow with heat and mass transfer of an electrically conducting, chemically reactive viscoelastic fluid in irregular channel with subject to convective boundary condition has been investigated. The perturbation technique is used to solve governing coupled nonlinear partial differential equations. Sreedevi *et al*. [11] studied radiation absorption, variable viscosity, Hall current of a MHD free-convective flow and double diffusion over a stretching sheet within the heat generation or absorption. Shateyi *et al* [12]. Investigated the effects of thermal radiation, Hall currents, Soret and Dufour effects on MHD mixed convection flow over a vertical surface in porous media, and they found that the fluid temperature increases due to an increase in the thermal radiation. Also they found that the concentration decreases as the radiation parameter value is increased. Nabil *et al* [13] analyzed the flow of second grade fluid past on permeable infinite vertical plate absorbed in a porous medium and by including influences of thermophorsis, Soret, Hall, thermal radiation, heat generation and chemical reaction on the flow and in the presence of viscous dissipation. K. S. Reddy *et al.* [14] have studied unsteady MHD flow of a chemically reacting microplar fluid over an infinite vertical porous plate through a porous medium with Hall effects and thermal radiation in the presence of radiation absorption and heat sink equations using dimensionless variables. The dimensionless equations are then solved analytically using the perturbation technique. Nabil *et al.*[15] analyzed the flow of second grade fluid past on permeable infinite vertical plate immersed in a porous medium and by including influences of thermophorsis, Soret, Hall, thermal radiation, heat generation and chemical reaction on the flow and in the presence of viscous dissipation. Odelu Ojjela *et al* [16].consider unsteady two-dimensional incompressible Magneto Hydrodynamic flow and heat transfer of a microplar fluid in a porous medium between parallel plates with chemical reaction, Hall and ion slip effects. The flow is generated due to periodic suction or injection at the plates and the reduced flow field equations are solved numerically using the quasilinearization technique.

Combined heat and mass transfer problems with chemical reaction are received a significant amount of consideration in modern years. In processes such as drying, evaporation at the surface of water body, energy transfer in wet cooling tower, and the flow in a desert cooler, heat and mass transfer occur simultaneously. Chemical reaction can be codified as either homogeneous or heterogeneous processes. A homogeneous reaction is one that occurs uniformly through a given phase. In contrast, a heterogeneous reaction takes place in a restricted region or within the boundary of a phase. A reaction is said to be first order, if the rate of reaction is directly proportional to the concentration itself which has many applications in dissimilar chemical engineering processes and other industrial applications such as polymer production, manufacturing of ceramics or glassware, and food processing. Rajeswari *et al.* [17] have investigated chemical reaction, heat and mass transfer on nonlinear MHD boundary layer flow through a vertical porous surface in presence of suction. A detailed numerical study was carried out for unsteady Hydro Magnetic natural convection heat and mass transfer with chemical reaction over a vertical plate in rotating system with periodic suction by Parida *et al.* [18]. Cintaginjala *et al.* [19] investigated the effects of chemical reaction and thermo-diffusion on hydro magnetic free convective fluid flow past an infinite vertical plate in the presence of heat sink. Ibrahim *et al*. [20] analyzed the effects of the chemical reaction and radiation absorption on the unsteady Magneto Hydrodynamic free convection flow past a semi-infinite vertical permeable moving plate with heat source and suction. Chamkha [21] studied the Magneto hydrodynamic flow of a numerical of uniformly stretched vertical permeable surface in the presence of heat generation or absorption on chemical reaction. Jadish [22] studied the thermal-diffusion impact on MHD three dimensional natural convective Couette flows by employing perturbation technique with the presence of chemical reaction and the absence of Diffusion terms. Mythili *et al* [23] have studied Heat generating/absorbing and chemically reacting Casson fluid flow over a vertical cone and flat plate saturated with non-Darcy porous medium. Jasmine Benazir *et al* [24] have studied the effects of double dispersion, non-uniform heat source/sink and higher order chemical reaction on unsteady MHD Casson fluid flow over a vertical cone and flat plate saturated with porous medium.

The main objective of current study is consider an Influence of radiation and soret on MHD free convective flow through an oscillatory porous medium with constant suction velocity in presence of hall and ion-slip current. The modelling equations are transformed in to dimensionless equations and then solved analytically through multiple regular perturbation law. Computations were performed graphically to analyze the behaviour of fluid velocity, temperature and Concentration on the vertical plate with the difference of emerging physical parameters.

2. Mathematical formulation and solution of the problem:

Consider two-dimensional, unsteady, free convection with thermal radiation flow of a viscous, incompressible and electrically conducting fluid through a highly porous medium which is bounded by a vertical infinite plane surface under the influence of a transverse magnetic field. The fluid is supposed to be a gray, absorbing emitting but non-scattering medium. The x^*-axis is taken along the plane surface with a direction opposite to the direction of gravity and y^*-axis is taken to be normal to the surface. The physical variables are functions of y^* and the time t^* only. The radiate heat flux in the x^*- direction is considered negligible in comparison with that in y^* - direction. Hall and Ion slip current and heat source parameter has been taken into consideration. The magnetic Reynolds number of the flow is taken to be small enough, so that the induced magnetic field can be neglected. The homogeneous chemical reaction is of first order with rate constant *Kr* between the diffusing species and the fluid is considered. Therefore, the equation expressing the conservation of mass, momentum and energy within a concentration boundary layer are given by

Equation of continuity:

$$\frac{\partial v^*}{\partial y^*}=0 \qquad (1)$$

$$\Rightarrow v^*=-v_0 \qquad (2)$$

Equation of Momentum:

$$\left.\begin{aligned}&\frac{\partial u^*}{\partial t^*}+v^*\frac{\partial u^*}{\partial y^*}=\frac{-1}{\rho}\frac{\partial p^*}{\partial y^*}+\vartheta\frac{\partial^2 u^*}{\partial y^{*2}}\\&+g\beta(T^*-T^*_\infty)+g\beta^*\left(C^*-C^*_\infty\right)\\&-\frac{\vartheta}{k^*}\left[u^*\right]-\frac{B_0^2\sigma_e\left[\alpha_e u^*+\beta_e w^*\right]}{\rho\left[\alpha_e^2+\beta_e^2\right]}\end{aligned}\right\} \qquad (3)$$

$$\left.\begin{aligned}&\frac{\partial w^*}{\partial t^*}+v^*\frac{\partial w^*}{\partial y^*}=\vartheta\left[\frac{\partial^2 w^*}{\partial y^{*2}}\right]-\frac{\vartheta}{k}w^*\\&-\left[\frac{B_0^2\sigma_e}{\rho\left(\alpha_e^2+\beta_e^2\right)}\right]\left(\beta_e\left(v_1^*-u^*\right)-\alpha_e w^*\right)\end{aligned}\right\} \qquad (4)$$

$$-\frac{1}{\rho}\frac{\partial p^*}{\partial y^*}=\frac{dv_1^*}{dt^*}+\frac{\vartheta}{k}v_1^*+\frac{\sigma_e}{\rho\left(\alpha_e^2+\beta_e^2\right)}B_0^2 v_1^* \qquad (5)$$

Equation of Energy:

$$\left.\begin{aligned}&\frac{\partial T^*}{\partial t^*}+v^*\frac{\partial T^*}{\partial y^*}=\alpha\left(\frac{\partial^2 T^*}{\partial y^{*2}}-\frac{1}{k_0}\frac{\partial q_r^*}{\partial y^*}\right)\\&\qquad+\frac{Q_0}{\alpha}(T^*-T^*_\infty)\end{aligned}\right\} \qquad (6)$$

$$\left.\begin{aligned}&\frac{\partial C^*}{\partial t^*}+v^*\frac{\partial C^*}{\partial y^*}=D\frac{\partial^2 C^*}{\partial y^{*2}}+\frac{DK_T}{T_m}\frac{\partial^2 T^*}{\partial y^{*2}}\\&\qquad-K_r(C^*-C^*_\infty)\end{aligned}\right\} \qquad (7)$$

The related boundary conditions are

$$\left.\begin{aligned}&at\ y^*=0:\begin{cases}u^*=0,w^*=0\\T^*=T^*_\infty,C^*=C^*_\infty\end{cases}\\&As\ y^*\to\infty:\begin{cases}u^*\to v_1^*=U_0(1+e^{i\omega t^*})\\w^*\to 0,T^*=T^*_\infty,C^*=C^*_\infty\end{cases}\end{aligned}\right\} \qquad (8)$$

From the equation (2)-(5) then we get

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$$\left.\begin{aligned}&\frac{\partial u^*}{\partial t^*}+v^*\frac{\partial u^*}{\partial y^*}=\frac{dv_1^*}{dt^*}+\vartheta\frac{\partial^2 u^*}{\partial y^{*2}}\\&-\frac{B_0^2\sigma_e}{\rho\left((1+\beta_i\beta_e)^2+\beta_e^2\right)}\left(\begin{pmatrix}1+\\ \beta_i\beta_e\end{pmatrix}(v_1^*-u^*)+\beta_e w^*\right)\\&+g\beta(T^*-T_\infty^*)+\frac{\vartheta}{K^*}(v_1^*-u^*)\end{aligned}\right\}\quad(9)$$

$$\left.\begin{aligned}&\frac{\partial w^*}{\partial t^*}+v^*\frac{\partial w^*}{\partial y^*}=\vartheta\left[\frac{\partial^2 w^*}{\partial y^{*2}}\right]-\frac{\vartheta}{k}w^*\\&-\frac{B_0^2\sigma_e}{\rho\left((1+\beta_i\beta_e)^2+\beta_e^2\right)}\begin{pmatrix}\beta_e(v_1^*-u^*)\\-(1+\beta_i\beta_e)w^*\end{pmatrix}\end{aligned}\right\}\quad(10)$$

$$q_r^*=-\frac{4\sigma}{3k_1}\frac{\partial T^{*4}}{\partial y^*}\qquad(11)$$

Now Non-dimensional quantities are defined as

$$\left.\begin{aligned}&f=\frac{u^*}{U_0},\ g=\frac{w^*}{U_0},\ y=\frac{V_0y^*}{\vartheta},\ v_1=\frac{v_1^*}{U_0}\\&t=\frac{V_0^2t^*}{\vartheta},\ U=\frac{U^*}{U_0},\ K=\frac{K^*\vartheta^2}{V_0^2}\\&T^*=T_\infty^*+\theta(T_w^*-T_\infty^*)\\&C^*=C_\infty^*+C(C_w^*-C_\infty^*)\end{aligned}\right\}\quad(12)$$

After substituting the boundary conditions and non-dimensional variables in the governing equations (3), (4), (6) & (7) then we get,

$$\left.\begin{aligned}&\frac{\partial f}{\partial t}-\frac{\partial f}{\partial y}=\frac{\partial^2 f}{\partial y^2}+\frac{dv_1}{dt}+G_r\theta+G_mC\\&-\frac{B_0^2\sigma_e\vartheta}{V_0^2\rho\left(\begin{pmatrix}1\\+\beta_i\beta_e\end{pmatrix}^2+\beta_e^2\right)}\left(\begin{pmatrix}1\\+\beta_i\beta_e\end{pmatrix}\begin{pmatrix}v_1\\-f\end{pmatrix}+\beta_eg\right)\\&+\frac{1}{k}(v_1-f)\end{aligned}\right\}\quad(13)$$

$$\left.\begin{aligned}&\frac{\partial g}{\partial t}-\frac{\partial g}{\partial y}=\frac{\partial^2 g}{\partial y^2}-\frac{1}{k}g\\&-\frac{B_0^2\sigma_e\vartheta}{V_0^2\rho\begin{pmatrix}(1+\beta_i\beta_e)^2\\+\beta_e^2\end{pmatrix}}\begin{pmatrix}\beta_e(v_1-f)\\-(1+\beta_i\beta_e)g\end{pmatrix}\end{aligned}\right\}\quad(14)$$

$$\frac{\partial\theta}{\partial t}-\frac{\partial\theta}{\partial y}=\frac{1}{\Pr}\left(\begin{aligned}&\left(1+\frac{4R}{3}(\theta+\phi)^3\right)\frac{\partial^2\theta}{\partial y^2}\\&+4R(\theta+\phi)^2\left(\frac{\partial\theta}{\partial y}\right)^2\end{aligned}\right)+\eta\theta\quad(15)$$

$$\frac{\partial C}{\partial t}-\frac{\partial C}{\partial y}=(Sc)^{-1}\frac{\partial^2 C}{\partial y^2}+Sr\,\theta''-K_rC\qquad(16)$$

The boundary conditions are

$$\left.\begin{aligned}&At\ y=0\quad f=0,\ g=0,\ \theta=1, C=1\\&As\ y\to\infty\quad \begin{cases}f=\left(1+\varepsilon e^{i\omega t}\right)\\ g\to0,\ \theta\to0,\ C\to0\end{cases}\end{aligned}\right\}\quad(17)$$

Take $F=f+i\,g$ (18)

$$\frac{\partial F}{\partial t}-\frac{\partial F}{\partial y}=\frac{dv_1}{dt}+\frac{\partial^2 F}{\partial y^2}+G_r\theta+N(v_1-F)\quad(19)$$

The boundary conditions are

$$\left.\begin{aligned}&At\ y=0\quad F=0,\ \theta=1, C=1\\&As\ y\to\infty\quad F=\left(1+\varepsilon e^{i\omega t}\right),\theta\to0, C\to0\end{aligned}\right\}\quad(20)$$

$$\left.\begin{aligned}&G_r=\frac{\vartheta\beta g(T_w^*-T_\infty^*)}{V_0^2U_0},\quad M=\frac{\sigma B_0^2}{\rho V_0^2}\\&\eta=\frac{\vartheta Q_0}{V_0^2\alpha},\quad K_r=\frac{k_1\vartheta}{V_0^2},\quad \Pr=\frac{\vartheta}{\alpha}\\&R=\frac{4\sigma(T_w^*-T_\infty^*)^3}{k_0k_1},\phi=\frac{T_\infty^*}{(T_w^*-T_\infty^*)}\\&Sc=\frac{\vartheta}{D},\quad Sr=\frac{(T_w^*-T_\infty^*)DK_T}{(C_w^*-C_\infty^*)\vartheta T_m}\\&N=\left[\frac{M}{\begin{pmatrix}(1+\beta_i\beta_e)^2\\+\beta_e^2\end{pmatrix}}\begin{pmatrix}(1+\beta_i\beta_e)\\+i\beta_e\end{pmatrix}+\frac{1}{k}\right]\end{aligned}\right\}\quad(21)$$

So as to solve the deferential equation (15), (16) & (19) it was suppose that

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$$\left.\begin{aligned} F &= F_0(y) + \varepsilon e^{i\omega t} F_1(y)\ldots\ldots \\ \theta &= \theta_0(y) + \varepsilon e^{i\omega t} \theta_1(y)\ldots\ldots\ldots \\ C &= C_0(y) + \varepsilon e^{i\omega t} C_1(y)\ldots\ldots\ldots \end{aligned}\right\} \quad (22)$$

From equation (15), (16), (19) & (22) then we get;

$$F_0'' + F_0' - NF_0 = -G_r\theta_0 - G_m C_0 - N \quad (23)$$

$$\left.\begin{aligned} F_1'' + F_1' - (N + i\,\omega)F_1 = -(N + i\,\omega) \\ - G_r\theta_1 - G_m C_1 \end{aligned}\right\} \quad (24)$$

$$\left.\begin{aligned} \left[1 + \frac{4}{3}R(\theta_0 + \phi)^3\right]\theta_0'' + 4R(\theta_0 + \phi)^2(\theta_0')^2 \\ + \Pr\theta_0' + \Pr\eta\,\theta_0 = 0 \end{aligned}\right\} \quad (25)$$

$$\left.\begin{aligned} &\left[1 + \frac{4}{3}R(\theta_0 + \phi)^3\right]\theta_1'' \\ &+ 8R(\theta_0 + \phi)^2(\theta_0')^2\theta_1 \\ &+ 8R\,(\theta_0 + \phi)^2\ \theta_0'\ \theta_1' \\ &+ 4\ R\ (\theta_0 + \phi)^2\theta_0''\ \theta_1 \\ &+\ \Pr\ \theta_1' - i\ \omega\ \Pr\ \theta_1 \\ &+ \Pr\eta\theta_1 = 0 \end{aligned}\right\} \quad (26)$$

$$C_0'' + Sc\ C_0' - Sc\ K_r\ C_0 = -Sr\ Sc\ \theta_0'' \quad (27)$$

$$C_1'' + Sc\ C_1' - Sc\,(K_r + i\omega)C_1 = -Sc\theta_1'' \quad (28)$$

The corresponding boundary conditions are

$$\left.\begin{aligned} &\left.\begin{aligned} F_0 = 0, F_1 = 0, \theta_0 = 1, \theta_1 = 0 \\ C_0 = 1, C_1 = 0 \end{aligned}\right\} : at\ y = 0 \\ &\left.\begin{aligned} F_0 = 1, F_1 = 1, \theta_0 \to 0, \theta_1 \to 0 \\ C_0 \to 0, C_1 \to 0 \end{aligned}\right\} : as\ y \to \infty \end{aligned}\right\} \quad (29)$$

If we suppose that the radiation parameter R to be small, we expand the velocity and temperature as

$$\left.\begin{aligned} F_0 &= F_{01}(y) + R\ F_{02}(y)\ldots\ldots\ldots \\ F_1 &= F_{11}(y) + R\ F_{12}(y)\ldots\ldots\ldots \\ \theta_0 &= \theta_{01}(y) + R\ \theta_{02}(y)\ldots\ldots\ldots \\ \theta_1 &= \theta_{11}(y) + R\ \theta_{12}(y)\ldots\ldots\ldots \\ C_0 &= C_{01}(y) + R\ C_{02}(y)\ldots\ldots\ldots \\ C_1 &= C_{11}(y) + R\ C_{12}(y)\ldots\ldots\ldots \end{aligned}\right\} \quad (30)$$

From the equation (22)-(25) & equation (29) then we obtain:

$$F_{01}'' + F_{01}' - NF_{01} = -Gr\theta_{01} - G_m C_{01} - N \quad (31)$$

$$F_{02}'' + F_{02}' - NF_{02} = -Gr\theta_{02} - G_m C_{02} \quad (32)$$

$$\left.\begin{aligned} F_{11}'' + F_{11}' - (N + i\omega)F_{11} = -(N + i\omega) \\ - Gr\theta_{11} - G_m C_{11} \end{aligned}\right\} \quad (33)$$

$$F_{12}'' + F_{12}' - (N + i\omega)F_{12} = -Gr\theta_{12} - G_m C_{12} \quad (34)$$

$$\theta_{11}'' + \Pr\theta_{11}' + (\eta - i\omega)\Pr\theta_{11} = 0 \quad (35)$$

$$\theta_{01}'' + \Pr\theta_{01}' + \Pr\eta\theta_{01} = 0 \quad (36)$$

$$\left.\begin{aligned} \theta_{02}'' + \frac{4}{3}(\theta_{01} + \phi)^3\theta_{01}'' + 4(\theta_{01} + \phi)^2(\theta_{01}')^2 \\ + \Pr\theta_{02}^1 + \Pr\eta\ \theta_{02} = 0 \end{aligned}\right\} \quad (37)$$

$$\left.\begin{aligned} &\theta_{12}'' + \frac{4}{3}(\theta_{01} + \phi)^3\theta_{11}'' + 8(\theta_{01} + \phi)^2(\theta_{01}')^2\theta_{11} \\ &+ 8(\theta_{01} + \phi)^2\theta_0^1\theta_{11}^1 + \Pr\theta_{12}' + 4(\theta_{01} + \phi)^2\theta_0''\theta_{11} \\ &+ \Pr(\eta - i\omega)\theta_{12} = 0 \end{aligned}\right\} \quad (38)$$

$$C_{01}'' + ScC_{01}' - Sc\ Kr\ C_{01} = -Sc\ Sr\ \theta_{01}'' \quad (39)$$

$$C_{02}'' + ScC_{02}' - Sc\ Kr\ C_{02} = -Sc\ Sr\ \theta_{02}'' \quad (40)$$

$$C_{11}'' + ScC_{11}' - Sc\,(Kr + i\omega)\ C_{11} = -Sc\ Sr\ \theta_{11}'' \quad (41)$$

$$\left.\begin{aligned} C_{12}'' + ScC_{12}' - Sc\,(Kr + i\omega)\ C_{12} = \\ - Sc\ Sr\ \theta_{12}'' \end{aligned}\right\} \quad (42)$$

The corresponding boundary conditions are

$$\left.\begin{aligned} &\left.\begin{aligned} F_{01} = 0, F_{02} = 0, F_{11} = 0, F_{12} = 0 \\ \theta_{11} = 0, \theta_{12} = 0, \theta_{01} = 1, \theta_{02} = 0 \\ C_{01} = 1, C_{02} = 0, C_{11} = 0, C_{12} = 0 \end{aligned}\right\} at\ \ y = 0 \\ &\left.\begin{aligned} F_{01} = 1, F_{02} = 0, F_{11} = 1, F_{12} = 0 \\ \theta_{01} = 0, \theta_{02} = 0, \theta_{11} = 0, \theta_{12} = 0 \\ C_{01} = 0, C_{02} = 0, C_{11} = 0, C_{12} = 0 \end{aligned}\right\} at\ \ y \to \infty \end{aligned}\right\} \quad (43)$$

$$\theta_{01} = e^{-R_2 y} \quad (44)$$

$$F_{01} = H_2 e^{-R_3 y} + S_6 e^{-R_2 y} + S_7 e^{-m_2\ y} + 1$$

$$F_{11} = e^{-R_4 y} \quad (45)$$

$$\left.\begin{aligned} \theta_{02} = A_2\ e^{-R_2 y} + N_2 e^{-4R_2 y} + N_3 e^{-R_2 y} \\ + N_4 e^{-3R_2 y} + N_5 e^{-2R_2 y} \end{aligned}\right\} \quad (46)$$

$$\left.\begin{aligned} F_{02} = H_3\ e^{-R_3 y} + S_8 e^{-m_2 y} + S_9 e^{-R_2 y} \\ + S_{10} e^{-4R_2 y} + S_{11} e^{-3R_2 y} + S_{12} e^{-2R_2 y} \end{aligned}\right\} \quad (47)$$

$$C_{01} = H_1 e^{-m_2 y} + S_1 e^{-R_2 y} \quad (48)$$

$$\left.\begin{aligned} C_{02} = H_2\ e^{-m_2 y} + S_2 e^{-R_2 y} + S_3 e^{-4R_2 y} \\ + S_4 e^{-3R_2 y} + S_5 e^{-2R_2 y} \end{aligned}\right\} \quad (49)$$

Substituting equations (44) – (49) in the equation (30) then we get velocity, temperature and concentration.

$$\left.\begin{array}{l} F = \left(H_2 e^{-R_3 y} + S_6 e^{-R_2 y} + S_7 e^{-m_2 y} + 1\right) \\ +R \begin{pmatrix} H_3 \; e^{-R_3 y} \; + \; S_8 e^{-m_2 y} \; + \; S_9 e^{-R_2 y} \\ +S_{10} e^{-4R_2 y} + S_{11} e^{-3R_2 y} + S_{12} e^{-2R_2 y} \end{pmatrix} \\ \qquad + \varepsilon e^{i\omega t}\left(e^{-R_4 y}\right) \end{array}\right\} \quad (50)$$

$$\theta = e^{-R_2 y} + R \begin{pmatrix} A_2 \; e^{-R_2 y} + N_2 e^{-4R_2 y} \\ +N_3 e^{-R_2 y} + N_4 e^{-3R_2 y} \\ + N_5 e^{-2R_2 y} \end{pmatrix} \quad (51)$$

$$\left.\begin{array}{l} C = H_1 \; e^{-m_2 y} + S_1 \; e^{-R_2 y} + R \; H_2 \; e^{-m_2 y} \\ +S_2 e^{-R_2 y} + S_3 e^{-4R_2 y} + S_4 e^{-3R_2 y} + S_5 e^{-2R_2 y} \end{array}\right\} \quad (52)$$

3. Results and Discussions:

The disparity in velocity profile with y for dissimilar values in Modified Grashof number is shown in **Fig 1:** The modified Grashof number Gm defines the ratio of the species buoyancy force to the viscous hydrodynamic force. As expected, the fluid velocity raises as Grashof number Gm raises.The influence of Magnetic field on velocity profiles is as shown in the **Fig 2:** by keeping other parameters in rest. The propinquity of magnetic field in an electrically conducting fluid presents a force called "Lorentz force" which acts adjacent to the flow if the magnetic field is connected in the normal direction as considered in the present issue. This sort of resistive force has a tendency to back off the flow field. Additionally, it is observed that the velocity of fluid reductions with expanding magnetic parameter. **Fig 3:** Shows the consequence of porous medium parameter *K* on the velocity. In this figure based on the outcomes it was found that the enhancement of *K* leads to rise in velocity. Causes existence of the porous medium in the flow furnishes confrontation to flow. Consequently, the result resistive force tends to sluggish the motion of the fluid along the surface of the plate. The variation in velocity profile with y for various values in Grashof numbers are shown in **Fig 4:** This figure reflects that with increase in *Gr* there is rise in fluid velocity due to improvement of the buoyancy force. **Fig 5:** Illustrates the performance of velocity for dissimilar estimators of Hall parameter β_e . From this figure it was observed that the enhancement of various values of hall parameter it leads to reduced in velocity and it is very near to the plate. Owing to the production of an extra prospective dissimilarity transverse to the direction of accumulate free charge and applied magnetic field among the opposite surfaces induces an electric current perpendicular to both the fields, magnetic as well as electric.

Fig 6: & **Fig 13:** displays distinction of velocity as well as concentration for diverse values of Soret parameter *Sr.* In this figure it was observed that the enhancement of dissimilar estimator's of soret parameter leads to ascend in concentration as well as velocity. The variation in velocity profile with y for various values in Ion-slip parameter is shown in **Fig 7:** From this figure it is clearly reflects that dissimilar values of Ion-slip parameter raises β_i leads to enhance in fluid velocity. **Fig 8:** & **Fig 12:** Illustrates the influence of the radiative-conduction parameter(*R*) on the velocity profile as well as temperature. From this figures it is evident that for different values of R rises then it leads to diminishes in velocity and temperature distributions. The influence of heat source parameter (η) on the temperature profile is shown in Fig 9: Form this figure it is obvious that temperature profile diminished with enhancement of heat source parameter. For diverse values of the Prandtl number *Pr* on the Temperature profile is plotted in **Fig 10:** Here it is find that as the values of Prandtl number *Pr* rises then it leads to diminished in temperature profile. The influence of temperature difference parameter ϕ is presented in the **Fig 11:** From this figure it is observed that temperature distribution diminished with the rise in temperature difference parameter. **Fig 14:** exhibits the influence of chemical reaction parameter *Kr* on Concentration. Here the incremental values of *Kr* lead to declined in concentration. Causes the chemical reaction improves momentum transfer moreover consequently accelerates the flow. For incongruent estimators of the Schmidt number on the fluid concentration is exposed in the **Fig 15:** from this figure the outcomes indicates that the enhancement of *Sc* leads to diminished in concentration. This causes the influence of concentration buoyancy to diminished, yielding a decline in the velocity. The depletion in the concentration is accompanied by instantaneous depletion in the concentration boundary layers, which is perceptible from the **Fig 15:**

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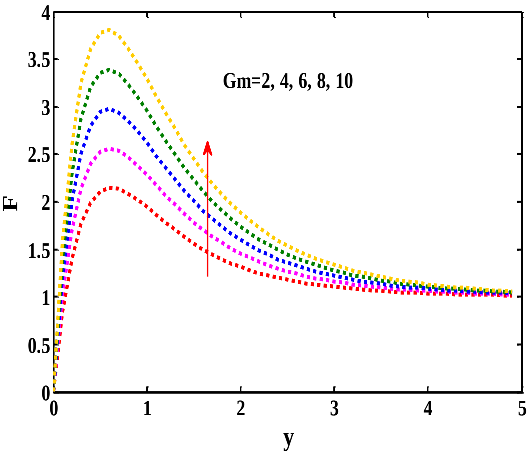

Fig 1: Influence of Gm on velocity

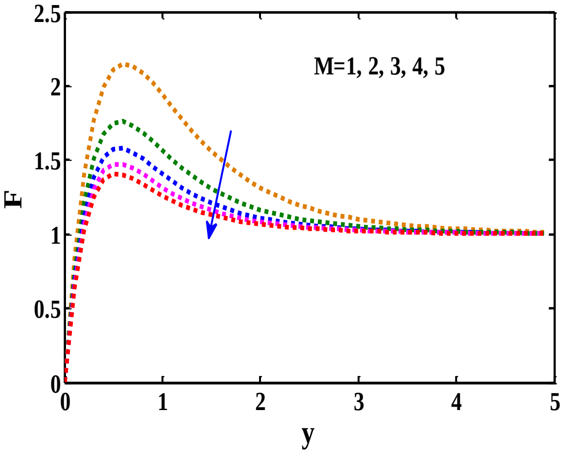

Fig 2: Influence of M on velocity

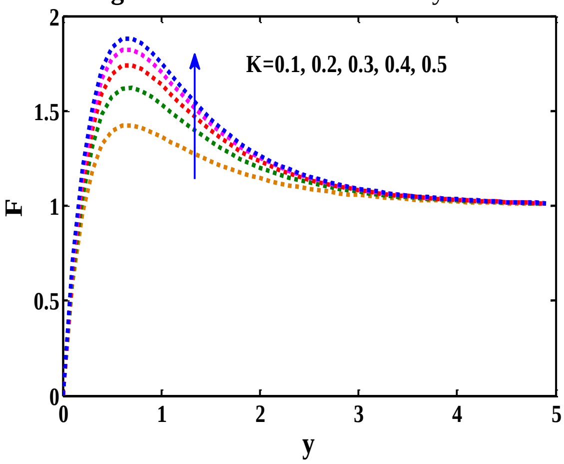

Fig 3: Influence of K on velocity

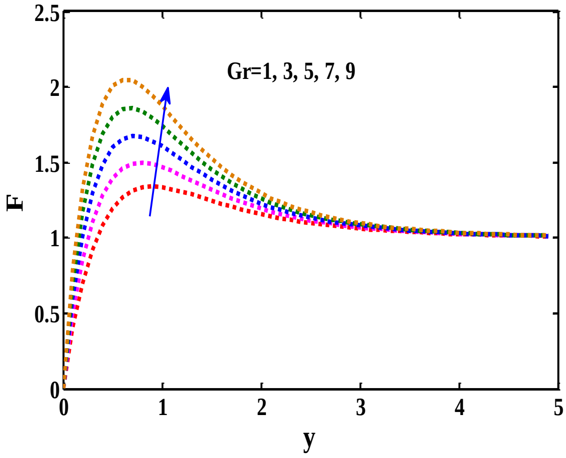

Fig 4: Influence of Gr on velocity

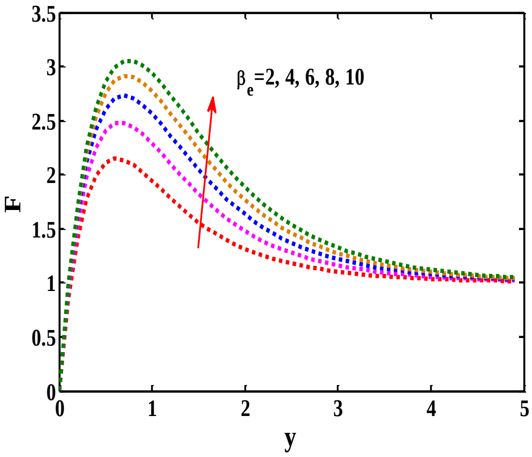

Fig 5: Influence of β_e on velocity

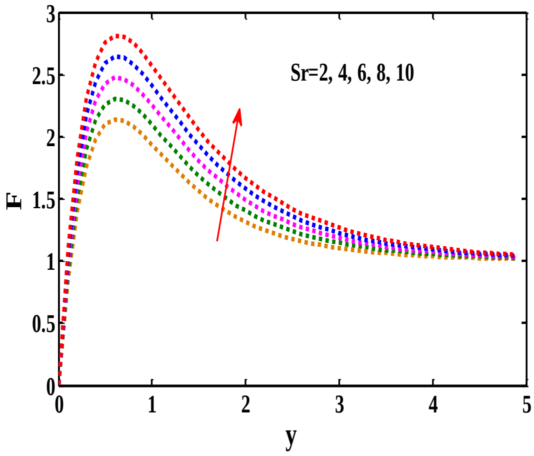

Fig 6: Influence of Sr on velocity

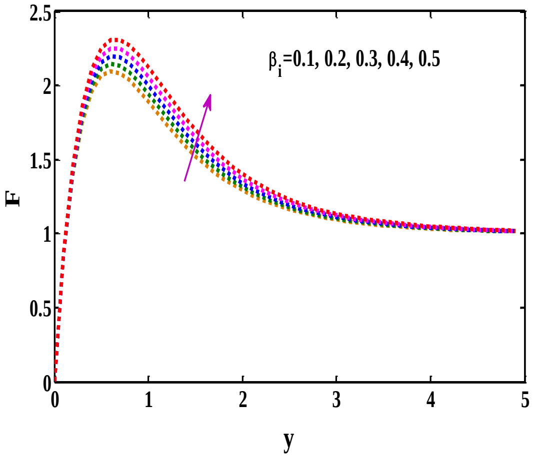

Fig 7: Influence of β_i on velocity

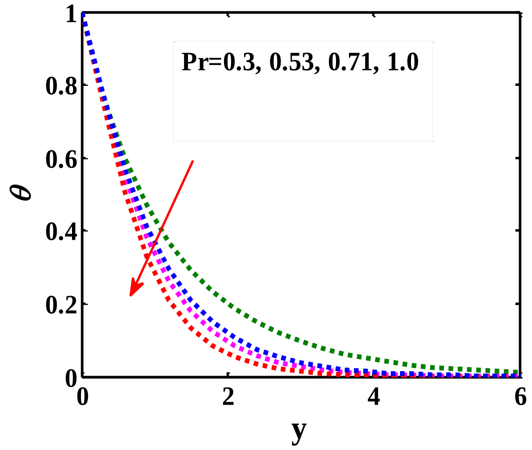

Fig 10: Influence of Pr on temperature

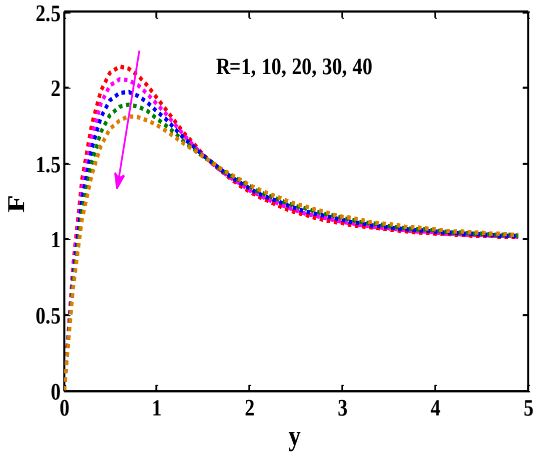

Fig 8: Influence of R on velocity

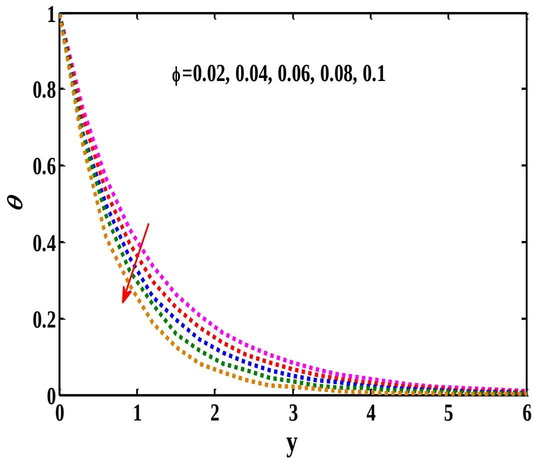

Fig 11: Influence of ϕ on temperature

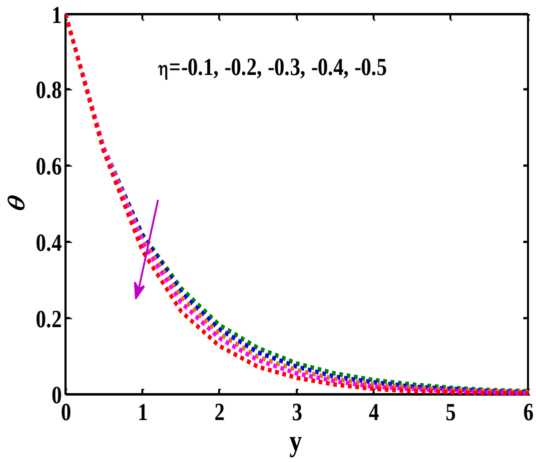

Fig 9: Influence of η on temperature

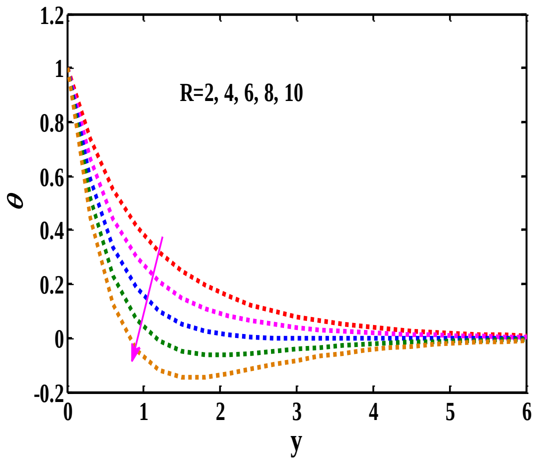

Fig 12: Influence of R on temperature

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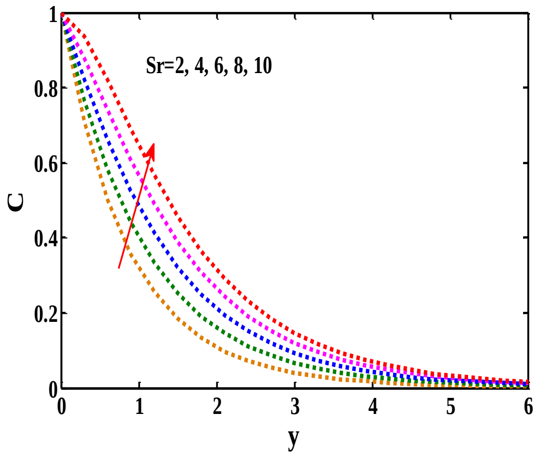

Fig 13: Influence of Sr on concentration

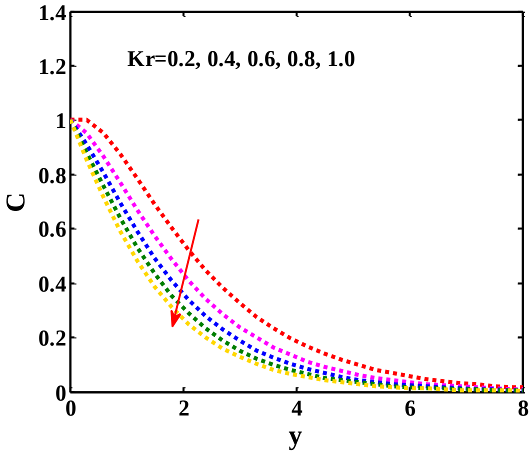

Fig 14: Influence of Kr on concentration

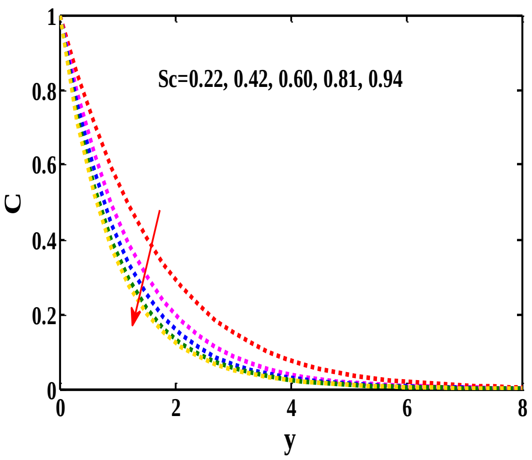

Fig 15: Influence of *Sc* on concentration

4. Conclusions:

- As the concentration diminish by means of the enhancement values of Schmidt number *Sc* and Chemical reaction Kr. But inverse effect was occurred in case of Soret *Sr*
- .As velocity and concentration declined with the incremental values of radiative conduction parameter.
- As velocity profile rises with the enhancement values of hall and ion slip current.
- As temperature diminished with the enhancement values of Pr.

5. Appendix:

$$R_2 = \frac{\Pr + \sqrt{(\Pr)^2 + 4\eta \Pr}}{2}$$

$$m_2 = \frac{Sc + \sqrt{(Sc)^2 + 4\,Sc\,Kr}}{2}$$

$$R_3 = \frac{1 + \sqrt{1+4N}}{2}$$

$$R_4 = \frac{1 + \sqrt{1+4(N+i\omega)}}{2}$$

$$N_1 = \frac{-Gr}{R_2^2 - R_2 - N}$$

$$N_2 = \frac{(-4/3)R_2^2}{16R_2^2 - 4\Pr R_2 + \Pr \eta}$$

$$N_3 = \frac{(-4/3)R_2^2\phi^3 + \phi^2 R_2}{R_2^2 - \Pr R_2 + \Pr \eta}$$

$$N_4 = \frac{(-4)R_2^2 + 4R_2}{9R_2^2 - 3\Pr R_2 + \Pr \eta}$$

$$N_5 = \frac{(-4)R_2^2\phi^2 + 8\phi}{4R_2^2 - 2\Pr R_2 + \Pr \eta}$$

$$N_6 = \frac{-GrA_2 - GrN_3}{R_2^2 - R_2 - N}$$

$$N_7 = \frac{-GrN_2}{16R_2^2 - 4R_2 - N}$$

$$N_8 = \frac{-GrN_4}{9R_2^2 - 3R_2 - N}$$

$$N_9 = \frac{-GrN_5}{4R_2^2 - 2R_2 - N}$$

$$N_{10} = \frac{-Gm}{l^2 - l - N}$$

$$S_1 = \frac{-Sc\ SrR_2^2}{R_2^2 - ScR_2 - Sc\ Kr}$$

$$S_2 = \frac{-Sc\ SrR_2^2\left(A_2 + N_3\right)}{R_2^2 - ScR_2 - Sc\ Kr}$$

$$S_3 = \frac{-Sc\ Sr\ 16\ R_2^2 N_2}{16R_2^2 - 4ScR_2 - Sc\ Kr}$$

$$S_4 = \frac{-9Sc\ Sr\ R_2^2 N_4}{9R_2^2 - 3ScR_2 - Sc\ Kr}$$

$$S_5 = \frac{-4Sc\ Sr\ R_2^2 N_5}{4R_2^2 - 2ScR_2 - Sc\ Kr}$$

$$S_6 = \frac{-(Gr + GmS_1)}{R_2^2 - R_2 - N}$$

$$S_7 = \frac{-(GmH_1)}{m_2^2 - m_2 - N}$$

$$S_8 = \frac{-(GmH_2)}{m_2^2 - m_2 - N}$$

$$S_{10} = \frac{-(GmS_3)}{16R_2^2 - 4R_2 - N}$$

$$S_{11} = \frac{-(GmS_4)}{9R_2^2 - 3R_2 - N}$$

$$S_{12} = \frac{-(GmS_5)}{4R_2^2 - 2R_2 - N}$$

$$A_1 = -(1 + N_1)$$

$$A_2 = -(N_2 + N_3 + N_4 + N_5)$$

$$A_3 = -(N_6 + N_7 + N_8 + N_9)$$

$$H_1 = 1 - S_1$$

$$H_2 = -\left(S_1 + S_2 + S_3 + S_4\right)$$

$$H_3 = -\left(S_6 + S_7 + 1\right)$$

$$H_4 = -\left(S_8 + S_9 + S_{10} + S_{11} + S_{12}\right)$$

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