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Influence of Hall and Ion-Slip Current on Span-Wisecosinusoidally Fluctuating MHD Free Convective Fluid Flow Past an Inclined Porous Plate with Chemical Reaction and Soret Effect

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Abstract
In this paper the influence of hall and ion-slip current on span-Wisecosinusoidally fluctuating MHD free convective fluid flow past an inclined porous plate with chemical reaction and Soret effect has been examined. The innovation of the present work was to analyze the effect of angle of inclination on the flow phenomena in the presence of heat source or sink and Soret effect. Perturbation method has been utilized to solve the governing equation. The influence of dissimilar parameters on velocity, temperature as well as concentration fields are shown graphically, In this examination it was found that as rise in hall and ion-slip current parameter leads to rise in velocity, but reverse effect was occurred in case of heat source, inclined angle and prandtl number. In addition concentration and velocity are declined with rise in Reynolds number and Soret parameter.
Keywords: *Hall and Ion-slip parameter, MHD, Soret Effect, Chemical reaction, Thermal Radiation and Porous Medium.*

1. Introduction

Magneto hydrodynamics is one of the significant developmental fields in contemporary scientific researches as well as engineering problems. Furthermore, this technical field can also be considered as a sub-discipline of fluid mechanics that deals with the mutual interactions among an externally imposed magnetic field and the flows of electrically conducting fluids. For so much of the currently published literature, the MHD free convective fluid flow phenomenon is tinted as the most fascinating problems in MHD and their associated fields. As of an application point of view, this sort of fluid flow has a great potential utilize in industrial, cleansing of molten metal's from non-metallic inclusions as well as fluid droplets-sprays, petroleum industry and particularly in many devices and equipments, such as MHD pumps and geothermal energy extractors, MHD power generators,. In addition, of these numerous applications, the MHD flow phenomenon can be encountered in a lot of fluid dynamics and heat transfer problems, especially in MHD flow of bio magnetic fluids, like human blood. This former topic is quite useful in different areas of bioengineering and medical sciences, which use the blood as the flowing biological fluid. Furthermore, it is renowned that the blood has a magnetic behavior and plays an indispensable role in transporting substrate drugs and other molecules through the human body between organs and tissues. The high temperatures in majority of industrial processes may not be uniform everywhere in the processing plants. In other words, these high temperatures may not necessarily be constant. They may vary over a period of time and at the same time may be different at different locations. In view of this a few studies have been conducted by considering span-wise cosinusoidal temperatures of the surfaces. Sumathi *et al*. [2] also studied heat and mass transfer in an unsteady three dimensional mixed convection flow past an infinite vertical porous plate with cosinusoidally fluctuating temperature. Kumar and Singh [3] studied an unsteady MHD flow of radiating and reacting fluid past a vertical porous plate with cosinusoidally fluctuating temperature. Alphonsa Mathew et al. [4] examined Span-wise fluctuating MHD convective heat and mass transfer flow through porous medium in a vertical channel with thermal radiation and chemical reaction. Paras Ram et al [5] Free convective boundary layer flow of radiating and reacting MHD fluid past a cosinusoidally fluctuating heated plate. Garg et al. [6] Hydro magnetic mixed convection flow through porous medium in a hot vertical channel with span wise co sinusoidal temperature and heat radiation has been investigated. Utpal Jyoti DAS et al. [7] analyzed unsteady MHD free convection and mass transfer flow of a viscoelastic, incompressible, electrically conducting fluid past an infinite hot vertical porous plate embedded in porous medium. Heat generation/absorption and viscous dissipation effects are incorporated. In this paper it was observed that temperature of the plate is supposed to be span wise cosinusoidally fluctuating with time. Anuradha S. [8] investigated heat and mass transfer of oscillatory free convective MHD flow past an infinite vertical porous plate with cosinusoidally fluctuating temperature. Garg et al. [9] discussed Injection/suction effect on spanwise sinusoidal fluctuating MHD mixed convection flow through porous medium in a vertical porous channel with thermal radiation. Krishan Dev Singh [10] analyzed exact solution of span-wise fluctuating MHD convective flow of second grade fluid through porous medium in a vertical channel with heat radiation and slip condition. Khem Khem Chand et al. [11] discussed Span-wise fluctuating hydromagnetic free convective heat transfer flow past a hot vertical porous plate with thermal radiation and viscous dissipation in slip flow regime. El-Hakiem et al. [12] and Makinde [13] examined constant suction velocity on MHD natural convective oscillatory flow with radiation through a porous medium. Raptis [14] analyzed analytically, the effect of non-constant 2D free convective flow throughout the motion of a viscous incompressible fluid through a very much porous medium. Gholizadeh [15] and Swathi [16] analyzed numerically, the influence of thermal as well as mass diffusion on MHD natural convective oscillatory flow through a perpendicular permeable plate through a porous medium with heat source**.** Rama Krishna et al. [17] focused on unsteady MHD free convective flow of a double diffusion fluid past a moving vertical porous plate with thermal radiation and chemical reaction. In this examination perturbation method was utilized for solving the governing equations. In the above all investigation Hall and Ion slip current was deserted.

The main objective of this paper is to analyze the influence of hall and ion-slip current on span-wise cosinusoidally fluctuating MHD free convective fluid flow past an inclined porous plate with chemical reaction and Soret effect. In this investigation the governing equations are solved by using perturbation method. In this investigation hall and ion-slip current is very important in fundamental in flows of lab plasma when a solid magnetic field of a uniform quality is connected and drawn the consideration of the analysis, because of their differed hugeness in fluid metals electrolytes arrive ionized gasses.

2. Formulation and solution of the problem:

Consider the flow of a conducting fluid past an infinite hot porous plate lying vertically on $x^*y^*z^*$ plane. The plate is supposed to be infinite in lengthened taken along the fluid in x^* direction, therefore all physical quantities are independent of x^* and is subjected to normally applied uniform magnetic field of strength $\boldsymbol{B_0}$. Let (u^*, v^*, w^*) be the components of the velocity in the (x^*, y^*, z^*) directions respectively. Owing to suction at the surface of the plate with constant velocity $v^* = -V$, w^* is independent of z^* and assumed as zero. Further, we assume that the magnetic Reynolds number is very small so that the induced magnetic field is negligible in comparison to the applied magnetic field. The fluid is considered here to be gray, absorbing/emitting radiation but a non-scatterering medium. No external electrical field is applied and effect of polarization of ionized fluid is negligible, therefore, electrical field is assumed to be zero. There exists a first order chemical reaction between the fluid and species concentration, the heat generation during chemical reaction cannot be neglected. The flow field is governed by the following set of equations.

Continuity equation:

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1}$$

Equation of momentum:

$$\left.\begin{aligned} \frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*} &= g\beta\left(T^* - T_\infty\right)\mathrm{Cos}\,\psi \\ &\quad -\frac{\upsilon}{k^*}u^* + \upsilon\left[\frac{\partial^2 u^*}{\partial y^{*2}} + \frac{\partial^2 u^*}{\partial z^{*2}}\right] \\ &\quad + g\beta^*\left(C^* - C_\infty\right)\mathrm{Cos}\,\psi \\ &\quad -\frac{\sigma_e B_0^2\left[\alpha_e u^* + \beta_e w^*\right]}{\rho\left[\alpha_e^2 + \beta_e^2\right]} \end{aligned}\right\} \tag{2}$$

$$\left.\begin{aligned} \frac{\partial w^*}{\partial t^*} + v^*\frac{\partial w^*}{\partial y^*} &= \upsilon\left[\frac{\partial^2 w^*}{\partial y^{*2}} + \frac{\partial^2 w^*}{\partial z^{*2}}\right] - \frac{\upsilon}{k^*}w^* \\ &\quad + \frac{\sigma_e B_0^2\left[\beta_e u^* - \alpha_e w^*\right]}{\rho\left[\alpha_e^2 + \beta_e^2\right]} \end{aligned}\right\} \tag{3}$$

Equation of energy

$$\left.\begin{aligned}\rho C_P\left[\frac{\partial T^*}{\partial t^*}+v^*\frac{\partial T^*}{\partial y^*}\right]=\kappa\left[\frac{\partial^2 T^*}{\partial y^{*2}}+\frac{\partial^2 T^*}{\partial z^{*2}}\right]\\ +Q_0\left(T^*-T_\infty\right)-\frac{\partial q_r}{\partial y^*}\end{aligned}\right\} \quad (4)$$

Equation of Concentration:

$$\left.\begin{aligned}\rho C_P\left[\frac{\partial C^*}{\partial t^*}+v^*\frac{\partial C^*}{\partial y^*}\right]=D\left[\frac{\partial^2 C^*}{\partial y^{*2}}+\frac{\partial^2 C^*}{\partial z^{*2}}\right]\\ -\Gamma\left(C^*-C_\infty\right)+D_1\left[\frac{\partial^2 T^*}{\partial y^{*2}}+\frac{\partial^2 T^*}{\partial z^{*2}}\right]\end{aligned}\right\} \quad (5)$$

Consider the temperature of the plate is to vary spanwise cosinusoidally fluctuation with time and suppose to be of the form:

$$T_w(z^*,t^*)=T_0+\varepsilon\left(T_0-T_\infty\right)\cos\left(\frac{\pi z^*}{l}-w^*t^*\right) \quad (6)$$

The corresponding initial and boundary conditions are as follows:

$$\left.\begin{aligned}&\left.\begin{aligned}&u^*=0,\\ &T^*=T_0+\varepsilon\left(T_0-T_\infty\right)\cos\left(\frac{\pi z^*}{l}-w^*t^*\right)\\ &C^*=C_w\end{aligned}\right\} at\ y^*=0\\ &\left.\begin{aligned}&u^*=0,\ T^*=T_0,\\ &C^*=C_0\end{aligned}\right\} \quad as \quad y\to\infty\end{aligned}\right\} \quad (7)$$

For the case of an optimality thin gray gas, local Radiative heat flux in the energy equation

$$\frac{\partial q_r}{\partial y^*}=4\sigma_s k_e\left(T^{*4}-T_\infty^4\right) \quad (8)$$

If the temperature differences within the flow are sufficiently small, then equation (7) can be linearized by expanding T^{*4} into the Taylors series about T^∞, which after neglecting higher order terms, takes the form

$$T^{*4}\cong 4T_\infty^3T^*-3T_\infty^4 \quad (9)$$

Form the equation (8), (9) and (4) the modified energy equation is

$$\left.\begin{aligned}\rho C_P\left[\frac{\partial T^*}{\partial t^*}+v^*\frac{\partial T^*}{\partial y^*}\right]=\kappa\left[\frac{\partial^2 T^*}{\partial y^{*2}}+\frac{\partial^2 T^*}{\partial z^{*2}}\right]\\ +Q_0\left(T^*-T_\infty\right)+16k_e\sigma T_\infty^3\left(T^*-T_\infty\right)\end{aligned}\right\} \quad (10)$$

The non-dimensional parameters as follows

$$\left.\begin{aligned}&y=\frac{y^*}{l},t=\omega^*t^*,u=\frac{u^*}{v},z=\frac{z^*}{l}\\ &k=\frac{k^*}{l},\ t=w^*t^*,\omega=\frac{\omega^*l^*}{v},z=\frac{z^*}{l}\\ &\gamma=\frac{l^2k_1}{v},\phi=\frac{C^*-C_\infty}{C_w-C_\infty},\theta=\frac{T^*-T_\infty}{T_w-T_\infty}\end{aligned}\right\} \quad (11)$$

Using the transformation (11) and equation (6), the momentum equation (2), (3), equation (10) and concentration equation (5) reduce to the following dimensionless form

$$\left.\begin{aligned}\omega\frac{\partial u}{\partial t}-Re\frac{\partial u}{\partial y}=Re^2Gr_1\theta+Re^2Gm_1C\\ +\left(\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)-\frac{u}{k}-M^2\frac{\left[\alpha_e u+\beta_e w\right]}{\left[\alpha_e^2+\beta_e^2\right]}\end{aligned}\right\} \quad (12)$$

$$\left.\begin{aligned}\omega\frac{\partial w}{\partial t}-\mathrm{Re}\frac{\partial w}{\partial y}=\left(\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)-\frac{w}{k}\\ -M^2\frac{\left[\beta_e u-\alpha_e w\right]}{\left[\alpha_e^2+\beta_e^2\right]}\end{aligned}\right\} \quad (13)$$

$$\left.\begin{aligned}\omega\frac{\partial\theta}{\partial t}-\mathrm{Re}\frac{\partial\theta}{\partial y}=\frac{1}{\mathrm{Pr}}\left(\frac{\partial^2\theta}{\partial y^2}+\frac{\partial^2\theta}{\partial z^2}\right)\\ -\left(\frac{R\ \mathrm{Re}}{\mathrm{Pr}}\right)\theta+\chi\ \theta\end{aligned}\right\} \quad (14)$$

$$\left.\begin{aligned}\omega\frac{\partial\phi}{\partial t}-\mathrm{Re}\frac{\partial\phi}{\partial y}=\frac{1}{Sc}\left(\frac{\partial^2\phi}{\partial y^2}+\frac{\partial^2\phi}{\partial z^2}\right)\\ -K_c\phi+So\left(\frac{\partial^2\theta}{\partial y^2}+\frac{\partial^2\theta}{\partial z^2}\right)\end{aligned}\right\} \quad (15)$$

The corresponding boundary conditions are

$$\left.\begin{aligned}&u=0,\theta=1+\varepsilon\cos(\pi z-t),\phi=1 at\ \ y=0\\ &u=0,\theta=0,\phi=0 as\qquad y\to\infty\end{aligned}\right\} \quad (16)$$

Where

$$\left.\begin{array}{l} Re=\frac{Vl}{\nu}, Gr=\frac{\nu g\beta(T_0-T_\infty)}{V^3}, R=\frac{16k_e\nu^2T_\infty^3}{kV^2} \\ Gm=\frac{\nu\ g\ \beta\ (C_0-C_\infty)}{V^3},\quad M^2=\frac{l\sigma_e B_0^2}{\nu} \\ Pr=\frac{\mu C_p}{k},\quad Sc=\frac{\nu}{D},\quad \chi=\frac{l^2\ Q_0}{\nu\ p\ C_p} \\ So=\frac{D}{\nu}\left(\frac{T_0-T_\infty}{C_0-C_\infty}\right), Gr_1=Gr\ \mathrm{Cos}\psi \\ Gm_1=Gm\ \mathrm{Cos}\psi\, N=\left[\frac{1}{k}+\frac{M^2[-\alpha_e+i\beta_e]}{[\alpha_e^2+\beta_e^2]}\right] \end{array}\right\} \quad (17)$$

Equations (12) and (13) are displayed, in a reduced form, as

$$\left.\begin{array}{l} \omega\frac{\partial F}{\partial t}-Re\frac{\partial F}{\partial y}=Re^2\ Gr_1\ \theta-NF \\ +Re^2Gm_1\ C+\left(\frac{\partial^2F}{\partial y^2}+\frac{\partial^2F}{\partial z^2}\right) \end{array}\right\} \quad (18)$$

The related boundary conditions are

$$\left.\begin{array}{ll} F=0,\theta=1+\varepsilon\cos(\pi z-t),\phi=1\, at\ y=0 \\ F=0,\theta=0,\phi=0\, as & y\to\infty \end{array}\right\} \quad (19)$$

To examine the influence of dissimilar parameters on velocity as well as temperature distributions in the boundary layer generated on the surface, the solution of partial differential equations [(14), (15) & (17)] in conjunction with boundary condition (19) is attained utilizing regular perturbation method similar to one used in Ramakrishna Reddy (2018) as well as Kumar and Singh (2011)through which is assumed the components of velocity, temperature and concentration respectively as follows:

$$\left.\begin{array}{l} F=F_0+\varepsilon F_1e^{i(\pi z-l)}+\varepsilon^2F_2e^{2i(\pi z-l)}\dots \\ \theta=\theta_0+\varepsilon\theta_1e^{i(\pi z-l)}+\varepsilon^2\theta_2e^{2i(\pi z-l)}\dots \\ \phi=\phi_0+\varepsilon\phi_1e^{i(\pi z-l)}+\varepsilon^2\phi_2e^{2i(\pi z-l)}\dots. \end{array}\right\} \quad (20)$$

Substituting equation (20) into set of equations (14), (15) & (18) and equating the like powers then we obtained

$$\left.\begin{array}{r} F_0''+\mathrm{Re}\,F_0'-N\ F_0=-Re^2\ Gr_1\ \theta_0 \\ -Re^2\ Gm_1\ \phi_0 \end{array}\right\} \quad (21)$$

$$\left.\begin{array}{r} F_1''+\mathrm{Re}\,F_1'-(N-wi)F_1=-Re^2\ Gr_1\theta_1 \\ -Re^2Gm_1\phi_1 \end{array}\right\} \quad (22)$$

$$\left.\begin{array}{r} F_2''+\mathrm{Re}\,F_2'-\left(N-2wi+4\pi^2\right)F_2= \\ -Re^2\ Gr_1\ \theta_2-Re^2\ Gm_1\ \phi_2 \end{array}\right\} \quad (23)$$

$$\theta_0''+Re\Pr\theta_0'-\left(Re^2R-Pr\ \chi\right)\theta_0=0 \quad (24)$$

$$\theta_1''+Re\Pr\theta_1'-\left(\pi^2+Re^2R-\chi Pr-iwPr\right)\theta_1=0 \quad (25)$$

$$\theta_2''+Re\Pr\theta_2'-\left(\begin{array}{l}\pi^2+Re^2R\ N\\ -\chi Pr-2iwPr\end{array}\right)\theta_1=0 \quad (26)$$

$$\left.\begin{array}{r} \phi_0''+Sc\ Re\ \phi_0'-Kc\ Sc\ \phi_0= \\ \left(\theta_0''-4\pi^2\theta_0\right)So\ Sc \end{array}\right\} \quad (27)$$

$$\left.\begin{array}{r} \phi_1''+ScRe\phi_1'-\left(\pi^2+KcSc-iwSc\right)\phi_1= \\ \left(-\theta_1''+\pi^2\theta_1\right)So\,Sc \end{array}\right\} \quad (28)$$

$$\phi_2''+ScRe\phi_2'-\left(\begin{array}{r}4\pi^2+KcSc\\ -2iwSc\end{array}\right)\phi_2=0 \quad (29)$$

The corresponding boundary conditions are

$$\left.\begin{array}{l} \left.\begin{array}{l} F_0=0,F_1=0,F_2=0 \\ \theta_0=1,\theta_1=1,\theta_2=0 \\ \phi_0=1,\phi_1=0,\phi_2=0 \end{array}\right\} at\quad y=0 \\ \left.\begin{array}{l} F_0=0,F_1=0,F_2=0 \\ \theta_0=0,\theta_1=0,\theta_2=0 \\ \phi_0=0,\phi_1=0,\phi_2=0 \end{array}\right\} at\quad y\to\infty \end{array}\right\} \quad (30)$$

Solve equation (21)-(29) and substituting in the equation (20) then we get velocity, temperature and concentration.

$$\left.\begin{array}{l} F=\left[\begin{array}{r}\left(-k_3-k_4\right)e^{-m_{13}y}+k_3e^{-m_1y} \\ +k_4e^{-m_7y}\end{array}\right] \\ +e^{i(\pi z-t)}\varepsilon\left[\left(\begin{array}{l}\left(-k_5-k_6\right)e^{-m_{15}y} \\ +k_5e^{-m_3y}+k_6e^{-m_9y}\end{array}\right)\right] \end{array}\right\} \quad (31)$$

$$\theta=\left[e^{-m_1y}\right]+\varepsilon\left[\theta_1e^{-m_3y}\right] \quad (32)$$

$$\left.\begin{array}{l} \phi=\left[\left(1-k_1\right)e^{-m_7y}+k_1e^{-m_1y}\right] \\ +\varepsilon\left[-k_2e^{-m_9y}+k_2e^{-m_2y}\right] \end{array}\right\} \quad (33)$$

3. Results and discussion:

The influence of thermal Grashof number (Gr) on velocity is illustrated in the **Fig 1:** From this figure it was noticed that the enhancement of dissimilar

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estimators of *Gr* leads to rise in velocity close to the plate and after attaining its peak value, it diminished and finally converges to its limiting value. In the absence of Hall as well as Ion slip parameter i.e. the velocity follow the equivalent pattern as given in Ramakrishna Reddy et al.[17]. **Fig 2:** Represents for dissimilar values of Hall parameter on the velocity. In this figure reflects that velocity rises with the enhancement of (β_e) near the plate and ultimately converges to its limiting value. Due 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 magnetic and electric. **Fig 3:** Shows that velocity variation for diverse values of Ion- slip parameter (β_i). From this figure the outcomes reflects that the incremental values of β_i leads to rise in velocity and it is very close to the plate and reached converging point it is depend on the hall. The influence of Magnetic field parameter *M* on the velocity is reported in the **Fig 4:** From this figure it was observed that the velocity reduced with the enhancement of *M*. Due to magnetic field exerts a retarding force on free convection flow. **Fig 5: &Fig 16:** Exhibits the influence of chemical reaction parameter *Kc* on velocity and concentration. Here the incremental values of *Kc* leads to reduced in velocity and concentration. Chemical reaction ($Kc > 0$) well-known as destructive reaction reduces the flow velocity. **Fig 6: & Fig 14:** Reflects that for diverse values of Soret (*So)* on velocity as well as concentration. From this figures it was found that velocity and concentration rises with the enhancement of Soret. **Fig 7:** Represents the influence of modified Grashof number *Gm* on the velocity. From this figure it is evident that for dissimilar incremental values of *Gm* leads to enhance in velocity. It is due to the fact that rise in the value of modified grashof number has the tendency to enhance the influence of mass buoyancy. The influence of Prandtl number *Pr* on the velocity and temperature is illustrated in the **Fig 8:** and **Fig 11:** From this figure is obvious that for diverse values of Pr rises then it leads to reduce in velocity and temperature. The fact that thermal boundary layer decreases with increased value of Pr. **Fig 9:** and **Fig 13:** Demonstrated that velocity and temperature profile due to the variations in heat source parameter χ. From these figures the results indicates that velocity declined with the rise in χ. Physically, in the presence of heat source parameter effects has the tendency to decline the fluid velocity across the momentum boundary layer. Due to the influence of thermal buoyancy to reduces, which results in a net reduction in the velocity. This type of behaviours is shown close to the plate. And also temperature declined with the rise in heat source parameter. **Fig 10:** Reflects that the influence of inclined angle ψ on the velocity. From this figure it was observed that fluid velocity diminished with the incremental values of inclined angle ψ. **Fig 12**: & **Fig 15:** Concerns with the effect of Reynolds number *Re* on temperature as well as concentration. From these figure it was observed that temperature and concentration diminished due to the incremental values of *Re*. **Fig 17:** Reported that the effect of Schmidt number Sc on concentration. Here this figure reflects that concentration declined with the rise in *Sc*. Physically it is obviously, since rise of *Sc* means decline of molecular diffusivity. That results in diminish of concentration boundary layer. Hence, the concentration of species is higher for small values of *Sc* and lower for large values of *Sc*.

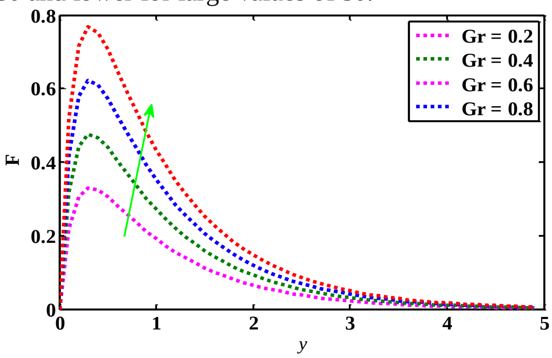

Fig 1: Influence of *Gr* on Velocity

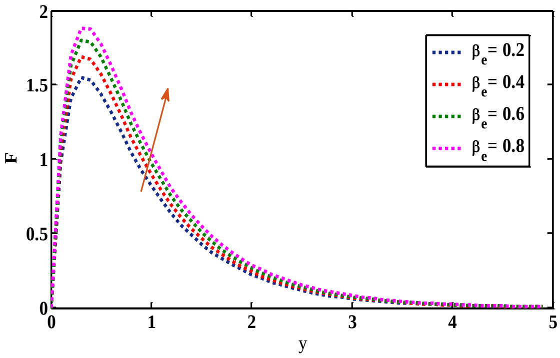

Fig 2: Influence of β_e on Velocity

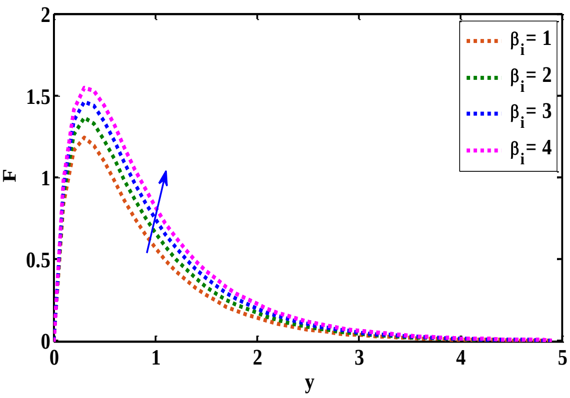

Fig 3: Influence of β_i on Velocity

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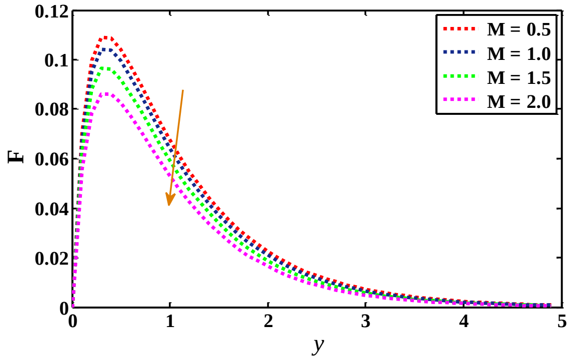

Fig 4: Influence of M on Velocity

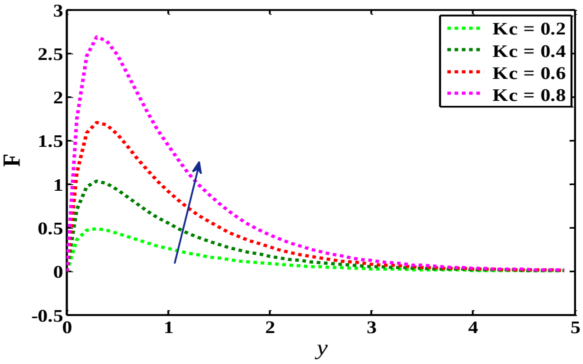

Fig 5: Influence of *Kc* on Velocity

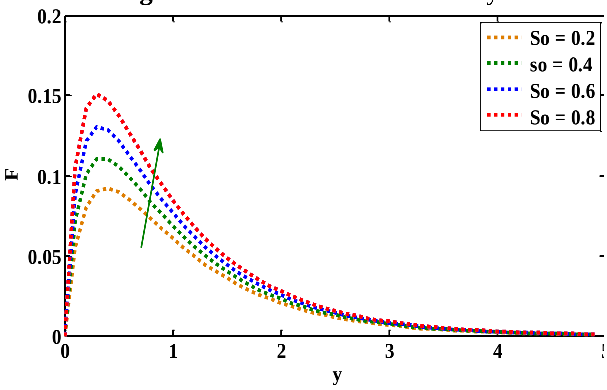

Fig 6: Influence of *So* on Velocity

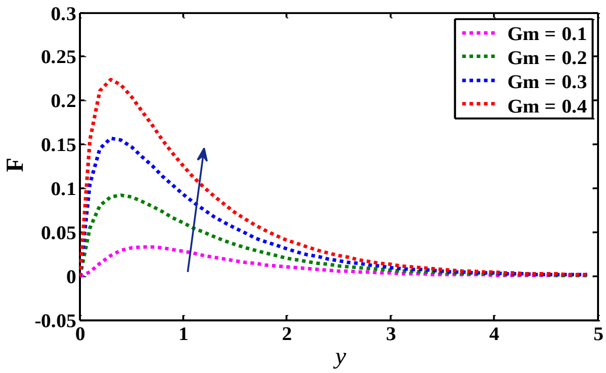

Fig 7: Influence of *Gm* on Velocity

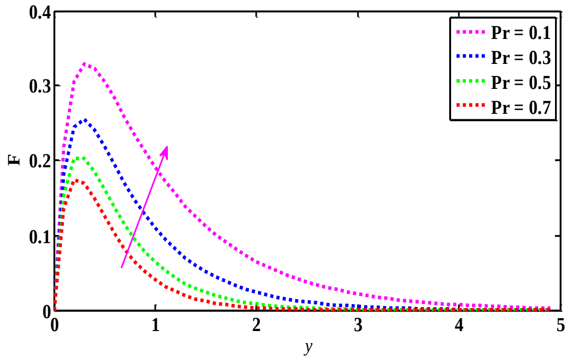

Fig 8: Influence of *Pr* on Velocity

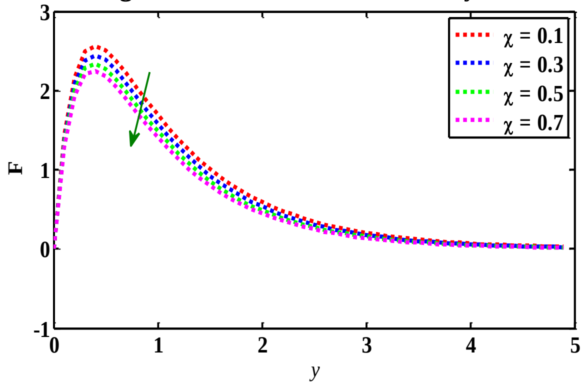

Fig 9: Influence of χ on Velocity

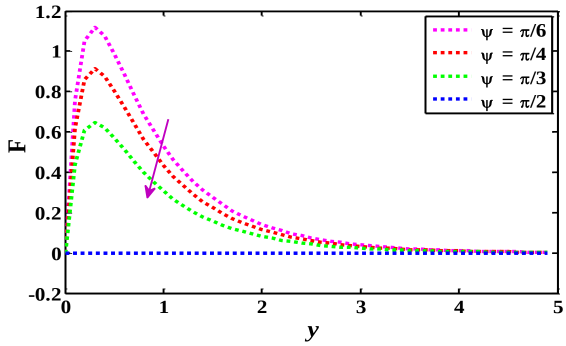

Fig 10: Influence of ψ on Velocity

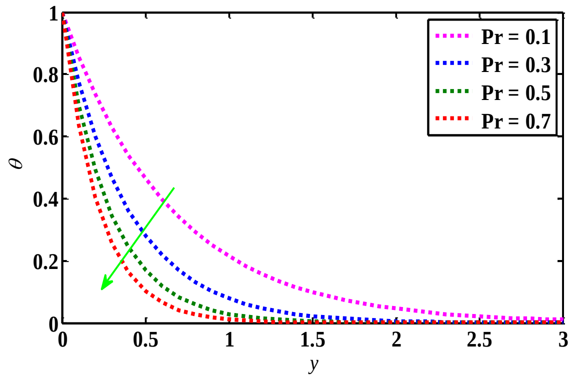

Fig 11: Influence of *Pr* on Temperature

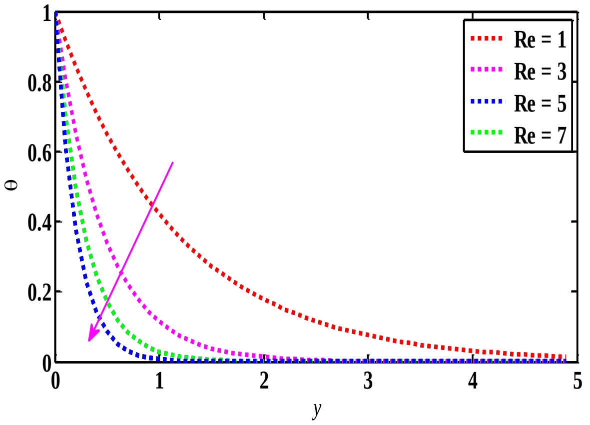

Fig 12: Influence of *Re* on Temperature

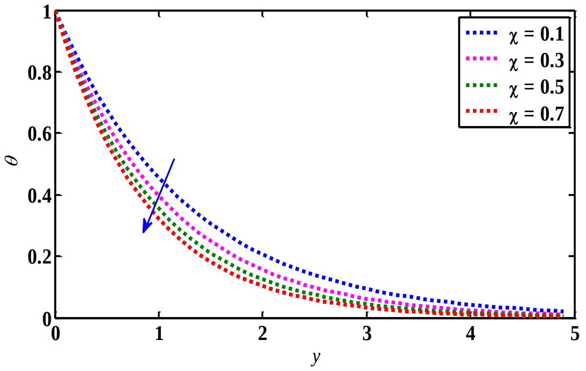

Fig 13: Influence of χ on Temperature

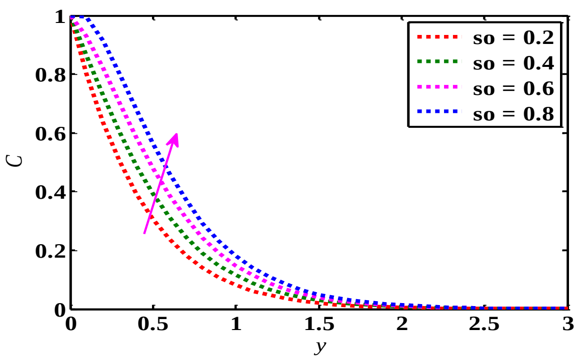

Fig 14: Influence of *So* on Concentration

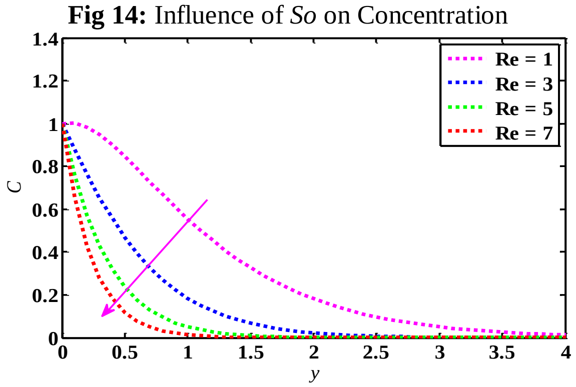

Fig 15: Influence of *Re* on Concentration

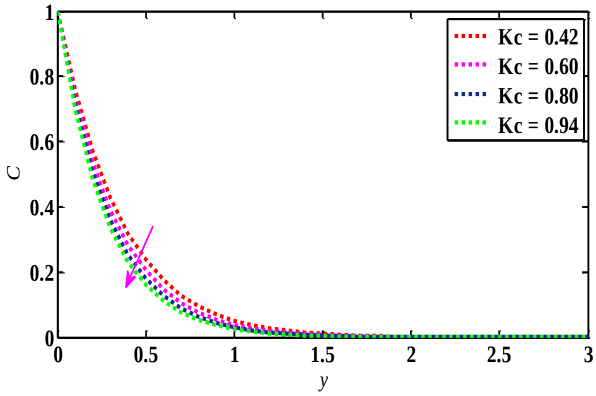

Fig 16: Influence of *Kc* on Concentration

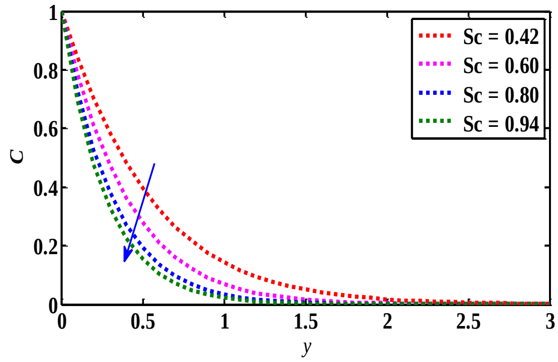

Fig 17: Influence of *Sc* on Concentration

4. Conclusions:

- The velocity and temperature diminished with the rise in Prandtl number (*Pr*) and heat source parameter (χ).
- The velocity declined with the rise in inclined angle ψ.
- As rise in Hall and ion-slip parameter, leads to rise in velocity.
- The velocity rises with the enhancement of Grashof number (*Gr*), modified Grashof number (*Gm*) and Soret number (So), but reverse effect was occurred in case of magnetic field.
- As Concentration and velocity declined then it leads to rise in chemical reaction, Reynolds number *Re* and Soret parameter.

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5. Appendix:

$$k_1 = \frac{\left(m_1^2 - 4\pi^2\right) So\ Sc}{m_1^2 - Sc\ Re\ m_1 - Kc\ Sc}$$

$$k_2 = \frac{\left(-m_3^2 + \pi^2\right) So\ Sc}{m_3^2 - Sc\ Re\ m_3 - \left(\pi^2 + Kc\ Sc - i\omega\ Sc\right)}$$

$$k_3 = \frac{-Re^2\left(Gr_1 + Gm_1\ k_1\right)}{m_1^2 - Re\ m_1 - N}$$

$$k_4 = \frac{-Re^2 Gm_1\left(1 - k_1\right)}{m_7^2 - Re\ m_7 - N}$$

$$k_5 = \frac{-Re^2\left(Gr_1 + Gm_1\ k_2\right)}{m_3^2 - Re\ m_3 - \left(N - i\omega\right)}$$

$$k_6 = \frac{-Re^2\left(Gm_1\ k_2\right)}{m_9^2 - Re\ m_9 - \left(N - i\omega\right)}$$