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SORET EFFECT ON TRANSIENT HYDROMAGNETIC OSCILLATORY CHANNEL FLOW WITH SLIP CONDITION IN PRESENCE OF HEAT SOURCE

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Om Prakash Sah***

Abstract

The problem of an oscillatory MHD mass transfer flow through a channel filled in a porous medium in presence of heat source, chemical reaction and thermal diffusion has been discussed. Fluid slip is imposed at the lower wall and the uniform magnetic field is assumed to be imposed transversely to the direction of the flow. The resultant governing equations are solved in closed form. The expressions for the velocity field, temperature field, concentration field, the coefficient of Skin-friction at the walls in the direction of the flow and the coefficient of the heat and mass transfer in term of Nusselt Number and Sherwood Number at the walls are obtained in non-dimensional form. The effects of Velocity slip, Solutal Grashof Number, Schmidt Number, Hartmann Number, Soret Number, Heat source Parameter, Chemical reaction parameter, and Radiation parameter on the flow and transport characteristics are studied through graphs and the results are physically interpreted for conclusions.

Keywords:

Magnetohydrodynamic;
Oscillatory-channel-Flow;
Slip Condition;
Heat Source;
Skin-friction.

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1. Introduction

In recent years, the studies on 'Magnetohydrodynamic(MHD) channel flow' are of keen interest among many researchers owing to their great importance in the field of industrial applications such as MHD generators, MHD pump, Nuclear reactors, etc. Significant works on various topics concerning MHD situations are seen in the works of Chang and Yen [1], Raptis [2], Singh [3] and many more. The effects of

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thermal radiation in MHD flows have also been a topic encountered in the area of modern engineering and science, particularly in space technology and other high temperature processes. Makinde and Mhone [4] investigated the effects of radiative heat transfer to MHD oscillatory flow in a channel filled with saturated porous medium. The Navier slip flow regime has been receiving attention of many researches. This is because of its applications in modern science, technology and industrialization. Owing to these applications, Makinde and Osalusi [5] presented the effects of slip conditions on the hydro-magnetic steady flow in a channel with permeable boundaries. The effects of Navier slip condition on the lower wall of unsteady MHD of a viscous fluid in a planner channel filled with saturated porous was reported by Mehmood and Ali [6]. It was established by Eegurjobi and Makinde [7] that the Navier slip boundary condition effect depends on the shear stress of both lower and upper walls of a channel. Recently, Adesanya and Makinde [8] investigated the Navier slip condition on the upper and lowers of pulsatile flow of oscillatory fluid through a channel filled with porous medium. In various chemical engineering processes, chemical reaction plays a vital role in design of chemical processing equipments and food processing. Disu et al [9] analyzed the effect of heat and mass transfer on MHD oscillatory slip flow in a channel filled with porous medium. Daniel et al [10] investigated the slip effect on MHD oscillatory flow of fluid in a porous medium with heat and mass transfer and chemical reaction. Earlier it was considered that, the mass transfer occur only due to concentration gradients. But after the pioneering work of Eckert and Drake [11], researchers believe that, in presence of high temperature gradient, species transportation may also take place. The process of mass transfer that occurs due to the combine effects of concentration as well as temperature gradients is known as thermal diffusion (Soret effect). Study on Soret effect was made by Platten and Chavepeyer [12], who investigated an oscillatory motion in Benard cell. Besides the aforesaid works, some more notable contribution in this regard are made by Jha and Singh [13], Dursunkaya and Worek [14] etc. Recently, Sengupta and Ahmed [15] obtained the closed form solution of the problem to investigate the chemical reaction interaction on unsteady MHD free convection radiative flow past an oscillating plate embedded in porous media with thermal diffusion.
The prime objective of the present work is to study the effect of thermal diffusion (Soret effect) on the flow and transport characteristics. Further it may be stated that our present work is a generalization of the work done by Ahmed and Sheikh [16] to include the thermal diffusion and heat generated source.

1. Mathematical Analysis

We consider an incompressible, viscous and electrically conducting fluid bounded by two parallel plates separated by a distance ***a***, filled with saturated porous medium under the influence of a uniform magnetic field applied normal to the plates. We assumed that the magnetic Reynolds number is so small that the induced magnetic field in comparison to applied magnetic field may be neglected.

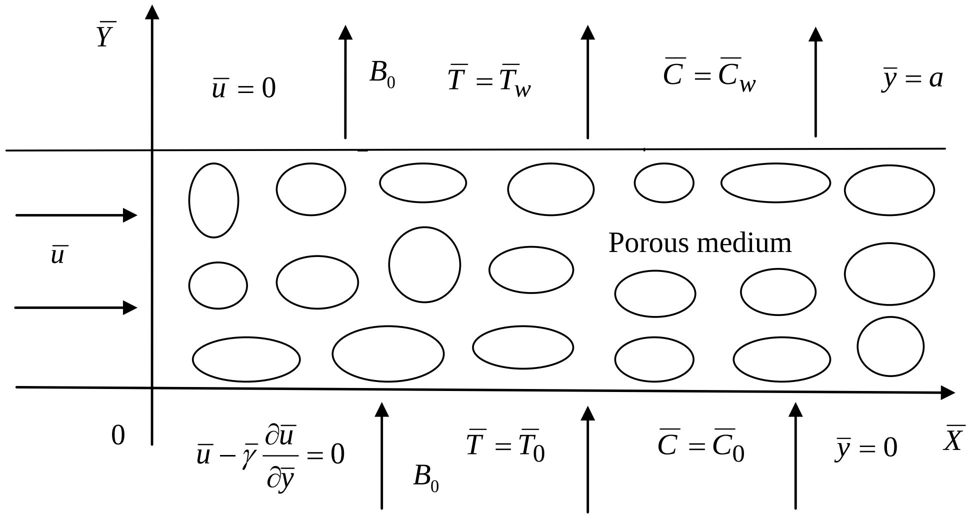


Figure 1: Flow configuration

We have considered cartesian coordinates system $(\overline{X},\overline{Y})$ where $\overline{X}$ -axis is taken along the lower plate and $\overline{Y}$ -axis along the upward normal to the plate. The governing equations are as follows.

Momentum equation:

$$\frac{\partial\overline{u}}{\partial\overline{t}}=-\frac{1}{\rho}\frac{\partial\overline{p}}{\partial\overline{x}}+\upsilon\frac{\partial^2\overline{u}}{\partial\overline{y}^2}-\frac{\upsilon}{\overline{K}}\overline{u}-\frac{\sigma B_0^2}{\rho}\overline{u}+g\beta(\overline{T}-\overline{T}_0)+g\beta(\overline{C}-\overline{C}_0) \tag{1}$$

Energy equation:

$$\frac{\partial\overline{T}}{\partial\overline{t}}=\frac{\kappa}{\rho C_p}\frac{\partial^2\overline{T}}{\partial\overline{y}^2}-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial\overline{y}}+\frac{Q_o(\overline{T}-\overline{T}_o)}{\rho C_p} \tag{2}$$

Species continuity equation:

$$\frac{\partial\overline{C}}{\partial\overline{t}}=D\frac{\partial^2\overline{C}}{\partial\overline{y}^2}+\overline{C}r(\overline{C}_0-\overline{C})+D_T\frac{\partial^2\overline{T}}{\partial\overline{y}^2} \tag{3}$$

The relevant boundary conditions are

$$\left.\begin{aligned}\overline{u}-\overline{\gamma}\frac{\partial\overline{u}}{\partial\overline{y}}=0,\ \overline{T}=\overline{T}_0,\ \overline{C}=\overline{C}_0\ \text{ at }\ \overline{y}=0\\ \overline{u}=0,\ \overline{T}=\overline{T}_w,\ \overline{C}=\overline{C}_w\ \text{ at }\ \overline{y}=a\end{aligned}\right\} \tag{4}$$

It is assumed that both walls temperatures $\overline{T}_0$, $\overline{T}_w$ are high enough to induce radiative heat transfer. We also assume that the fluid is optically thin with a relatively low density and the radiative heat flux following Cogley et al. [17] is given by

$$\frac{\partial q_r}{\partial\overline{y}}=4\alpha^2(\overline{T}_0-\overline{T}) \tag{5}$$

In order to make the mathematical model normalized, we introduce the following non-dimensional quantities:

$$Re=\frac{Ua}{\upsilon},\ x=\frac{\overline{x}}{a},\ y=\frac{\overline{y}}{a},\ u=\frac{\overline{u}}{U},\ \theta=\frac{\overline{T}-\overline{T}_0}{\overline{T}_w-\overline{T}_0},\ t=\frac{\overline{t}U}{a},\ p=\frac{a\overline{p}}{\rho\upsilon U},\ Da=\frac{\overline{K}}{a^2},$$

$$\phi=\frac{\overline{C}-\overline{C}_0}{\overline{C}_w-\overline{C}_0},\ Cr=\frac{a\overline{C}r}{U},\ M^2=\frac{a^2\sigma B_0^2}{\rho\upsilon},\ Gr=\frac{g\beta\left(\overline{T}_w-\overline{T}_0\right)}{\upsilon U}a^2,\ Pe=\frac{U\rho aC_p}{\kappa}$$

$$N^2=\frac{4\alpha^2a^2}{\kappa},\ Sc=\frac{\upsilon}{D},\ Gm=\frac{g\overline{\beta}\left(\overline{C}_w-\overline{C}_0\right)a^2}{\upsilon U},\ \gamma=\frac{\overline{\gamma}}{a},\ Q=\frac{Q_0a^2}{\kappa},\ Sr=\frac{D_T\left(\overline{T}_w-\overline{T}_0\right)}{\upsilon\left(\overline{C}_w-\overline{C}_0\right)}$$

All the physical quantities are defined in the Nomenclature.
The governing equations in non-dimensional form are

$$Re\frac{\partial u}{\partial t}=-\frac{\partial p}{\partial x}+\frac{\partial^2 u}{\partial y^2}-\left(s^2+M^2\right)u+Gr\theta+Gm\phi \tag{6}$$

$$Pe\frac{\partial\theta}{\partial t}=\frac{\partial^2\theta}{\partial y^2}+\left(N^2+Q\right)\theta \tag{7}$$

$$ReSc\frac{\partial\phi}{\partial t}=\frac{\partial^2\phi}{\partial y^2}-ReCrSc\phi+SrSc\frac{\partial^2\theta}{\partial y^2}, \quad \text{where } s=\left(\frac{1}{Da}\right)^{\frac{1}{2}} \tag{8}$$

The relevant boundary conditions in non-dimensional forms are

$$\left.\begin{aligned} &u-\gamma\frac{\partial u}{\partial y}=0,\ \theta=0,\ \phi=0 \text{ at } y=0\\ &u=0,\ \theta=1,\ \phi=1 \text{ at } y=1\end{aligned}\right\} \tag{9}$$

To solve the equations (6), (7) and (8) subject to the boundary condition (9), we consider the transformations:

$$\left.\begin{aligned} &-\frac{\partial p}{\partial x}=\lambda e^{i\omega t}\\ &u(y,t)=u_0(y)e^{i\omega t}\\ &\theta(y,t)=\theta_0(y)e^{i\omega t}\\ &\phi(y,t)=\phi_0(y)e^{i\omega t}\end{aligned}\right\} \tag{10}$$

Substituting the transformations (10), in (6), (7) and (8), we derive the following set of differential equations:

$$\frac{d^2u_0}{dy^2}-m_3^2u_0=-\lambda-Gr\theta_0-Gm\phi_0 \tag{11}$$

$$\frac{d^2\theta_0}{dy^2}+m_1^2\theta_0=0 \tag{12}$$

$$\frac{d^2\phi_0}{dy^2}-m_2^2\phi_0=-SrSc\frac{d^2\theta_0}{dy^2} \tag{13}$$

with boundary conditions:

$$\left.\begin{aligned} &u_0-\gamma\frac{\partial u_0}{\partial y}=0,\ \theta_0=0,\ \phi_0=0 \text{ at } y=0\\ &u_0=0,\ \theta_0=1,\ \phi_0=1 \text{ at } y=1\end{aligned}\right\} \tag{14}$$

where m_1, m_2 and m_3 are defined in the Appendix.

The equations (11) - (13) are solved subject to the boundary condition (14) and the solutions are as follows:

$$u(y,t)=\begin{bmatrix} C_1\cosh(m_3y)+C_2\sinh(m_3y)+\dfrac{\lambda}{m_3^2}+\dfrac{Gr}{\left(m_1^2+m_3^2\right)}\dfrac{\sin(m_1y)}{\sin(m_1)} \\ -\dfrac{Gm(1+A)}{\left(m_2^2-m_3^2\right)}\dfrac{\sinh(m_2y)}{\sinh(m_2)}-\dfrac{GmA}{m_1^2+m_3^2}\dfrac{\sin(m_1y)}{\sin(m_1)} \end{bmatrix}e^{i\omega t} \qquad (15)$$

$$\theta(y,t)=\frac{\sin(m_1y)}{\sin(m_1)}e^{i\omega t} \qquad (16)$$

$$\phi(y,t)=\left[(1+A)\frac{\sinh(m_2y)}{\sinh(m_2)}-A\frac{\sin(m_1y}{\sin(m_1)}\right]e^{i\omega t} \qquad (17)$$

where C_1, C_2 and A are defined in the Appendix.

3. Skin Friction

The shear stress distribution at any point in the fluid is specified by the Newton's law of viscosity as furnished below:

$$\bar{\tau}=-\mu\frac{\partial\bar{u}}{\partial\bar{y}}$$

$$=-\frac{\mu U}{a}\frac{\partial u}{\partial y}$$

$$\therefore\ \tau=\frac{\bar{\tau}}{\dfrac{\mu U}{a}}=-\frac{\partial u}{\partial y}$$

The Skin Frictions coefficients τ_0 and τ_1 on the plates at y=0 and y=1 respectively are specified by

$$\tau_0=-\left[\frac{\partial u}{\partial y}\right]_{y=0}$$

$$=-\left[C_2m_3+\frac{Gr}{\left(m_1^2+m_3^2\right)}\frac{m_1}{\sin(m_1)}-\frac{Gm(1+A)}{\left(m_2^2-m_3^2\right)}\frac{m_2}{\sinh(m_2)}-\frac{GmA}{\left(m_1^2+m_3^2\right)}\frac{m_1}{\sin(m_1)}\right]e^{i\omega t} \qquad (18)$$

and $$\tau_1=-\left[\frac{\partial u}{\partial y}\right]_{y=1}=-\begin{bmatrix} C_1m_3\sinh(m_3)+C_2m_3\cosh(m_3)+\dfrac{m_1Gr}{\left(m_1^2+m_3^2\right)}\dfrac{\cos(m_1)}{\sin(m_1)} \\ -\dfrac{m_2Gm(1+A)}{\left(m_2^2-m_3^2\right)}\dfrac{\cosh(m_2)}{\sinh(m_2)}-\dfrac{GmAm_1}{\left(m_1^2+m_3^2\right)}\dfrac{\cos(m_1)}{\sin(m_1)} \end{bmatrix}e^{i\omega t} \qquad (19)$$

4. Nusselt Number

The coefficient of the rate of heat transfer on the plates y=0 and y=1 in terms of the Nusselt number are given by

$$Nu_0=-\left[\frac{\partial\theta}{\partial y}\right]_{y=0}=-\frac{m_1}{\sin(m_1)}e^{i\omega t} \qquad (20)$$

and $$Nu_1 = -\left[\frac{\partial\theta}{\partial y}\right]_{y=1} = -\frac{m_1\cos(m_1)}{\sin(m_1)}e^{i\omega t} \quad (21)$$

5. Rate of Mass Transfer

The coefficient of the rate of mass transfer on the plates y=0 and y=1 to the fluid in terms of the Sherwood number is as described by

$$Sh_0 = -\left[\frac{\partial\phi}{\partial y}\right]_{y=0} = -\left[\frac{(1+A)m_2}{\sinh(m_2)} - \frac{Am_1}{\sin(m_1)}\right]e^{i\omega t} \quad (22)$$

and $$Sh_1 = -\left[\frac{\partial\phi}{\partial y}\right]_{y=1} = -\left[\frac{(1+A)m_2\cosh(m_2)}{\sinh(m_2)} - \frac{Am_1\cos(m_1)}{\sin(m_1)}\right]e^{i\omega t} \quad (23)$$

3. Results and Analysis

To get the insight of the physical problem, numerical computations from the analytical solutions are carried out for the Velocity field, Temperature field, Concentration field, Skin Frictions, Nusselt numbers and Sherwood numbers. The influence of the velocity slip (γ), Solutal Grashof Number (*Gm*), Schmidt Number (*Sc*), Chemical Reaction Parameter (*Cr*), Hartmann Number (*M*), Radiation Parameter (*N*), Soret Number, and Heat source parameter on the flow and, heat and mass transfer characteristics have been depicted graphically. We have focused to investigate the effects of γ, Gm, Sc, Cr, M, *N, Sr and Q* on the flow and transports characteristics. On the basis of this fact, the other parameters namely *Gr*, *Da*, *Re*, ω and λ are kept at unity for mathematical simplicity.

Further, Peclet number *Pe* is considered to be 0.71. Where, *Pe* = *Re* . *Pr*. It is already stated that *Re* =1 is considered in the present work. That is to say that *Pe* = *Pr* in the present investigation. As *Pe* is chosen to be 0.71, it is meant that *Pr*=0.71 is chosen indirectly for the present study that refers to air. In other words, we have considered air as the solvent which is optically thin.

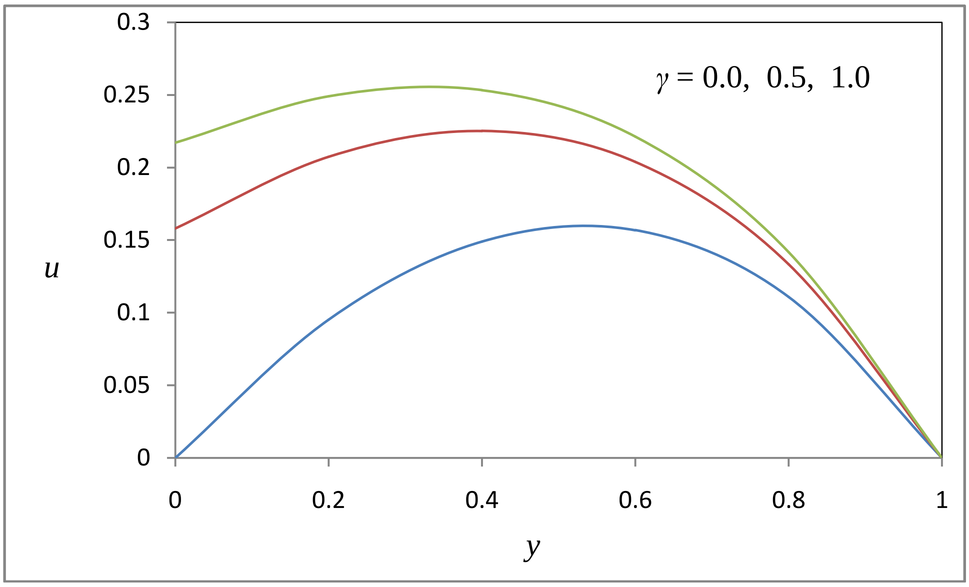


Figure 2: Velocity *u* against *y*, under γ for *Pe*=0.71, *Sc*=0.2, *Re*=1, *M*=1, *N*=1, *Da*=1, *Gr*=1, *Gm*=0, *Cr*=0, *Sr*=0, *Q*=0, $\omega=1,\ \lambda=1,\ t=0.$

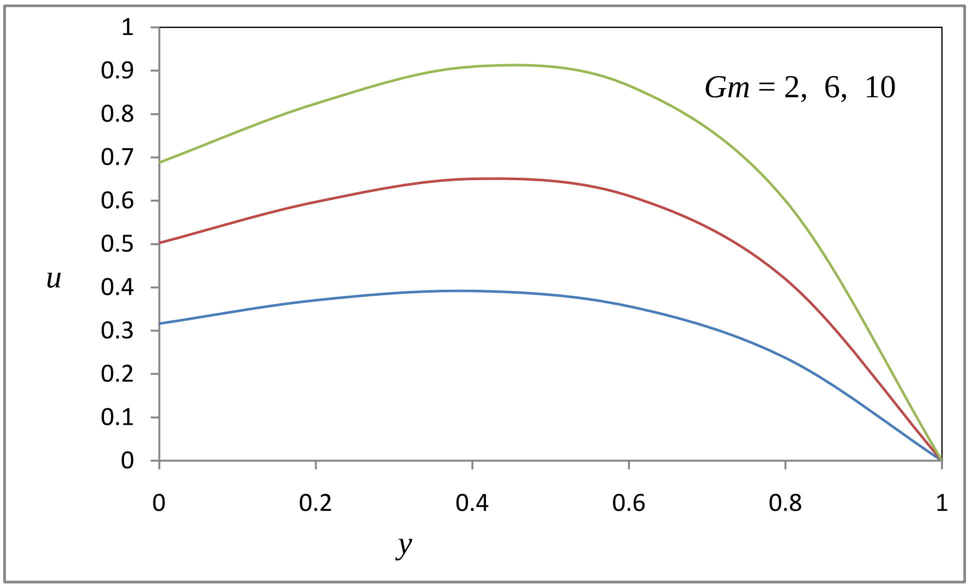


Figure 3: Velocity *u* against *y*, under *Gm* for *Pe*=0.71, *Sc*=0.2, *Re*=1, *M*=1, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *Sr*=1, *Q*=1, $\omega=1,\ \lambda=1,\ \gamma=1,\ t=0.$

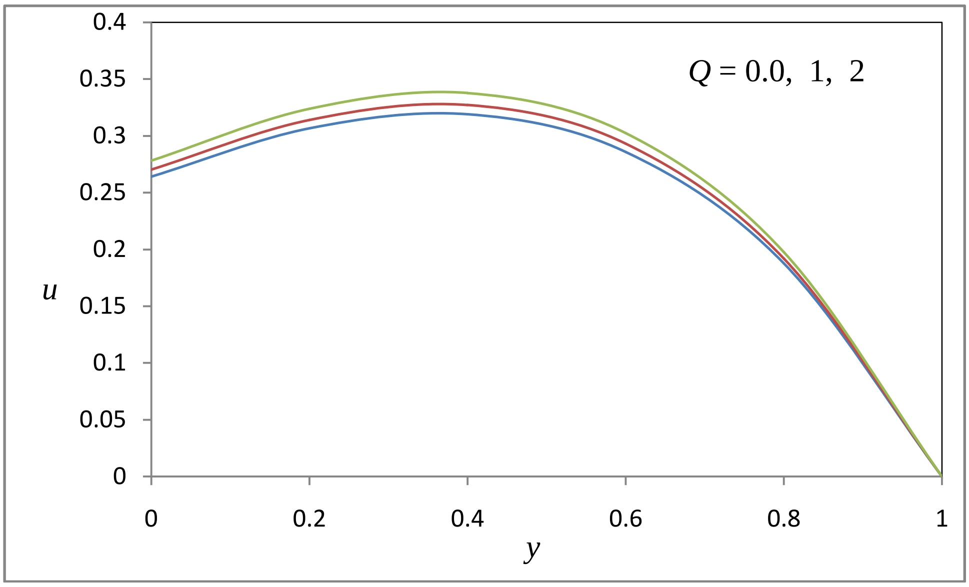


Figure 4: Velocity *u* against *y*, under *Q* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Sr*=1, $\omega=1,\ \lambda=1,\ \gamma=1,\ t=0.$

Figures 2, 3 and 4 depict how the slip parameter (γ), Solutal Grashof Number (*Gm*) and Heat source parameter (*Q*) have their effect on velocity field (*u*). These figures show that the fluid gets accelerated due to increasing slip parameter, Solutal Grashof number or Heat source parameter (Q). Thus we see that an increase in slip parameter has the tendency to reduce the frictional forces which increase the fluid velocity. Further it is evident that a rise in concentration buoyancy force causes a corresponding increase in the fluid velocity.

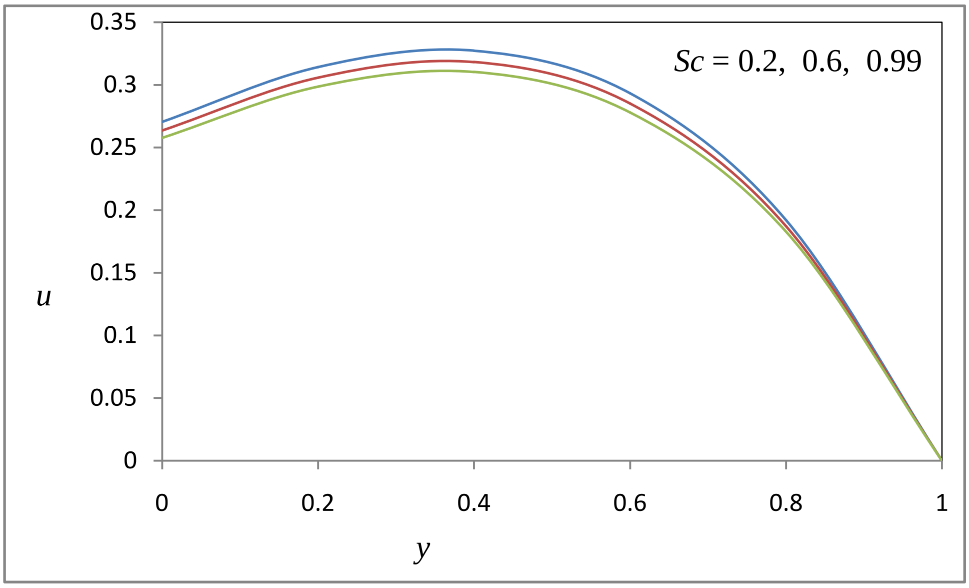


Figure 5: Velocity u against y, under Sc for Pe=0.71, Gm=1, Re=1, M=1, N=1, Da=1, Gr=1, Cr=1, Sr=1, Q=1, $\omega=1,\ \lambda=1,\ \gamma=1,\ t=0$.

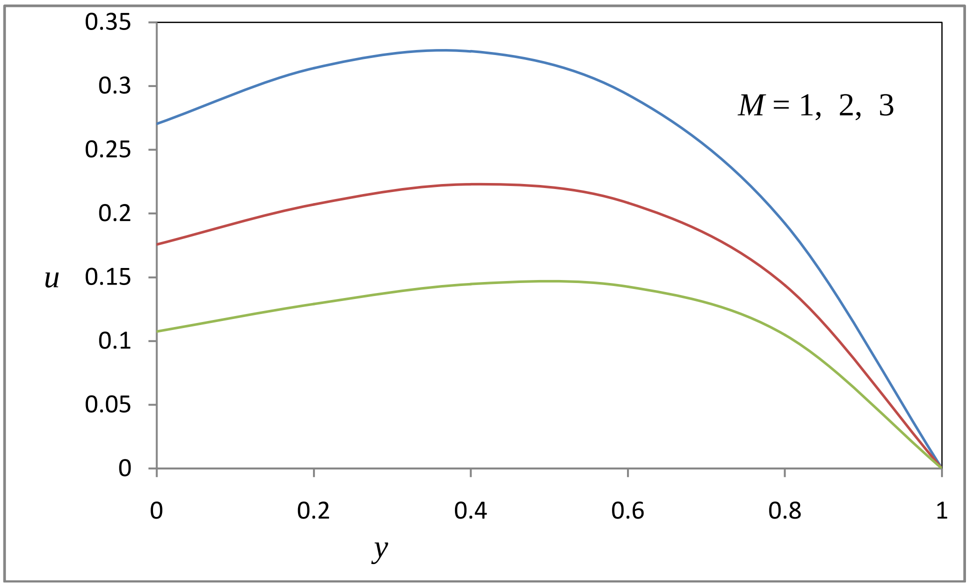


Figure 6: Velocity u against y, under M for Pe=0.71, Gm=1, Re=1, Sc=0.2, N=1, Da=1, Gr=1, Cr=1, Sr=1, Q=1, $\omega=1,\ \lambda=1,\ \gamma=1,\ t=0$.

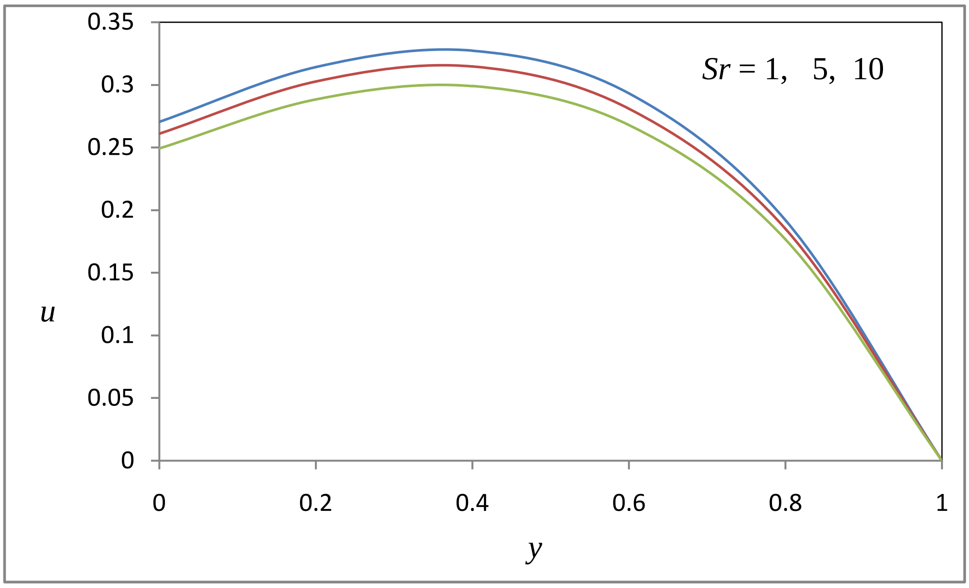
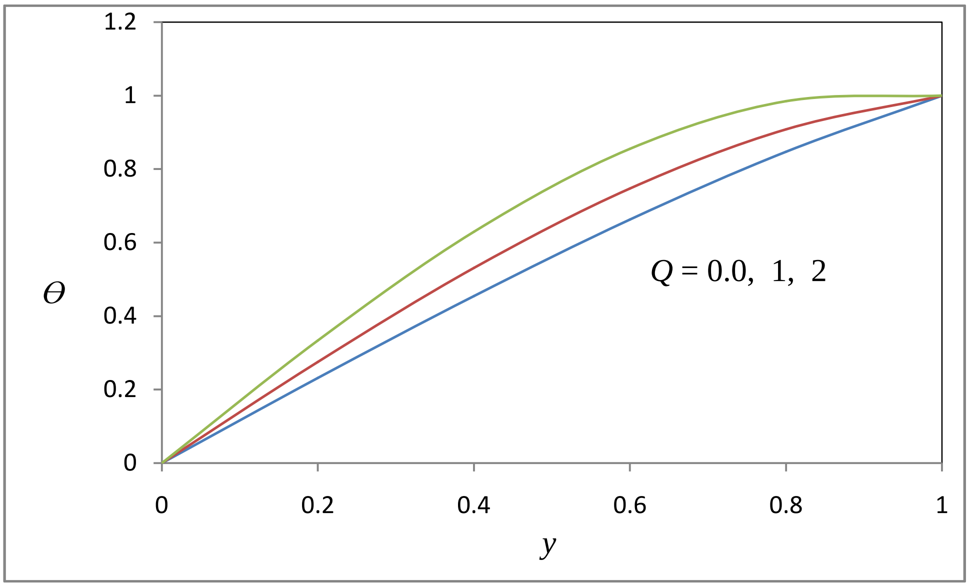


Figure 7: Velocity *u* against *y*, under *Sr* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Q*=1, $\omega = 1,\ \lambda = 1,\ \gamma = 1,\ t = 0$.

The figures 5, 6 and 7 demonstrate the behaviour of the velocity field under the influence of Schmidt number (*Sc*), Hartmann number (*M*) and Soret number (*Sr*). These figures show that the flow is decelerated for increasing values of Schmidt number, Hartmann number or Soret number. That is, an increase in Schmidt number means a decrease in mass diffusivity. This observation has an excellent agreement to the physical fact that the fluid moves freely as it becomes less dense due to high mass diffusivity. Further we recall that an increase in magnetic field intensity leads to a fall in fluid velocity. This phenomenon agrees to the expectations, that the magnetic field exerts a retarding force on the flow. Also, figure 7 indicates that the thermal diffusion retards the flow.



❖ Figure 8: Temperature field θ against *y*, under *Q* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Sr*=1, $\omega = 1,\ \lambda = 1,\ \gamma = 1,\ t = 0$.

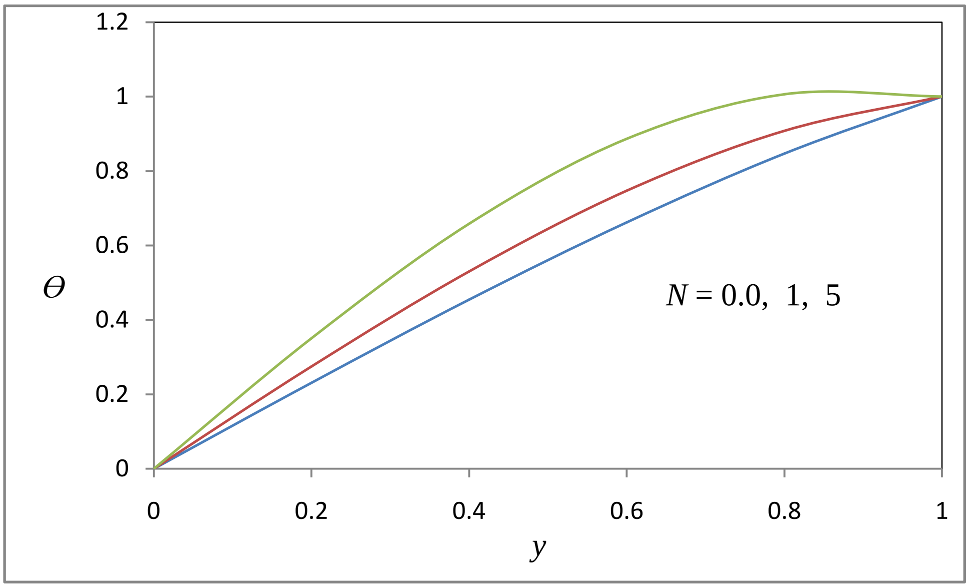


Figure 9: Temperature field θ against *y*, under *N* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *Q*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Sr*=1, $\omega=1$, $\lambda=1$, $\gamma=1$, $t=0$.

The figures 8 and 9 exhibit the behaviour of the temperature distribution (θ) due to variation of heat source parameter (*Q*) and radiation parameter (*N*). These figures show that the fluid temperature rises as parameter heat source or radiation parameter increases.

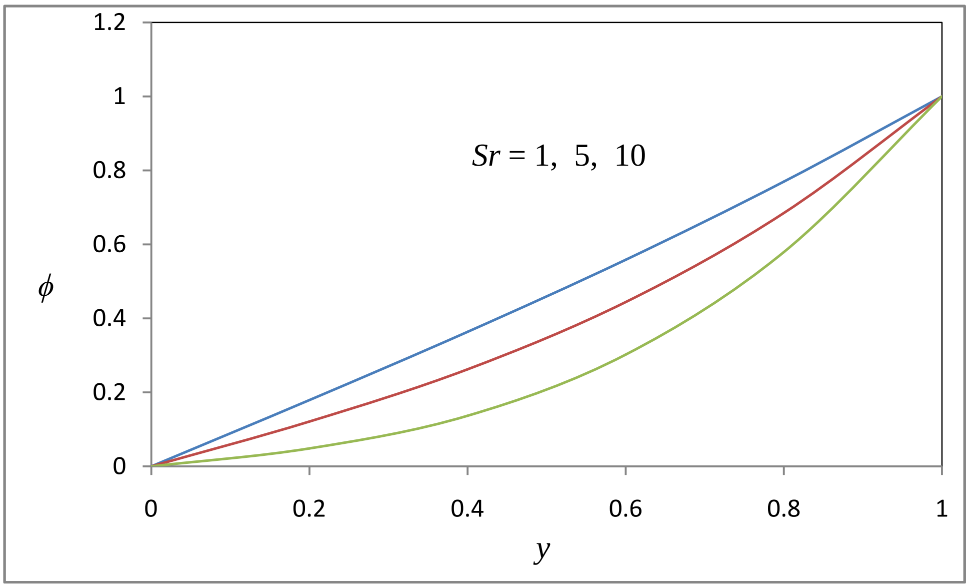


Figure 10: Concentration field ϕ against *y*, under *Sr* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Q*=1, $\omega=1$, $\lambda=1$, $\gamma=1$, $t=0$.

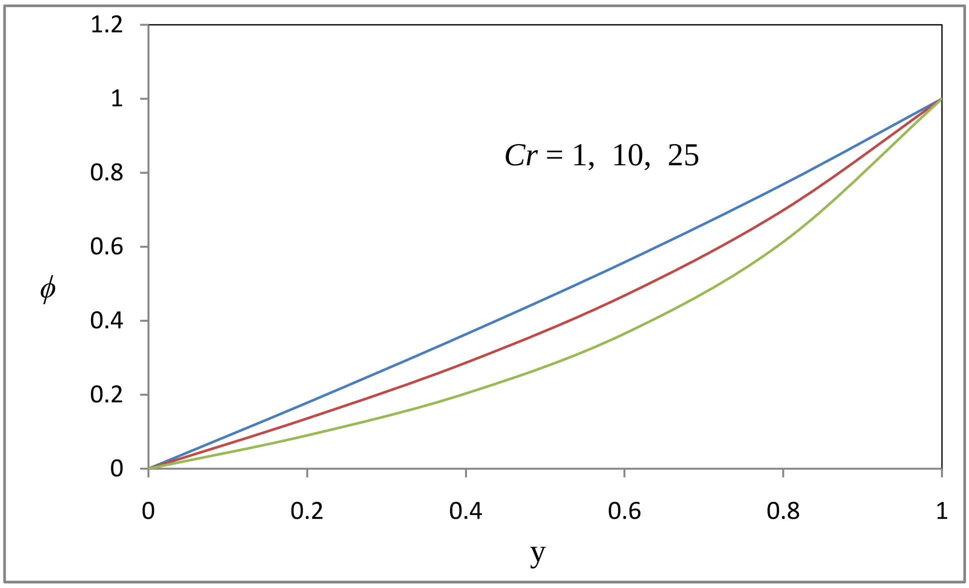


Figure 11: Concentration field ϕ against *y*, under *Cr* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Sr*=1, *M*=1, *Q*=1, $\omega = 1,\ \lambda = 1,\ \gamma = 1,\ t = 0$.

The Figures 10 and 11 represent the behaviour of the concentration field (ϕ) under the influence of Soret number (*Sr*) and chemical reaction parameter (*Cr*). These Figures show that, there is a substantial increase in the concentration level of the fluid under the effect of thermal diffusion or chemical reaction. It is found that as the chemical reaction parameter increases, the concentration of the fluid particles near the wall decreases. In the other words, in presence of chemical reaction the mass diffusivity decreases, and this results in a reduction of the thickness on the concentration boundary layer and ultimately the value of concentration ϕ.

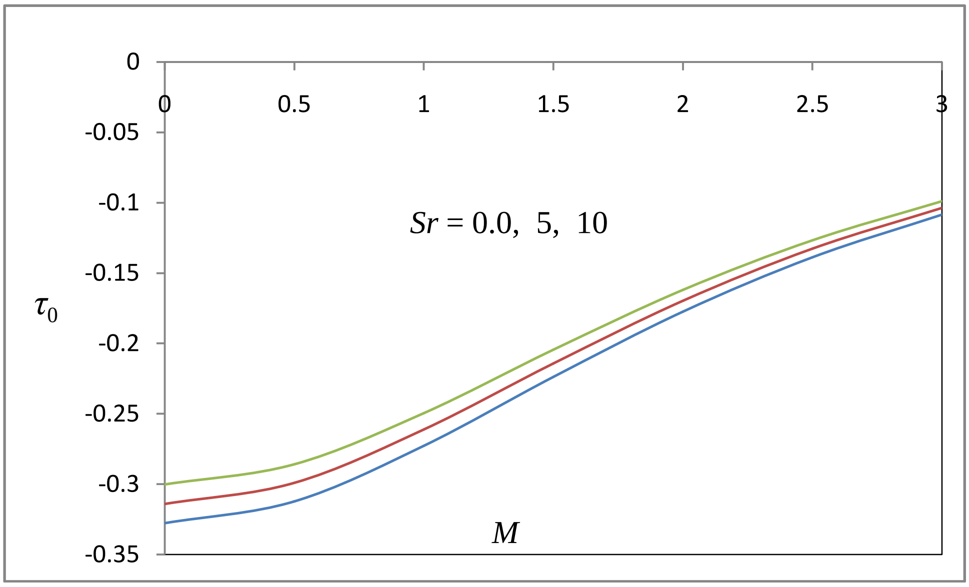


Figure 12: Skin friction τ_0 against *M*, under *Sr* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *Q*=1, $\omega = 1,\ \lambda = 1,\ \gamma = 1,\ t = 0$.

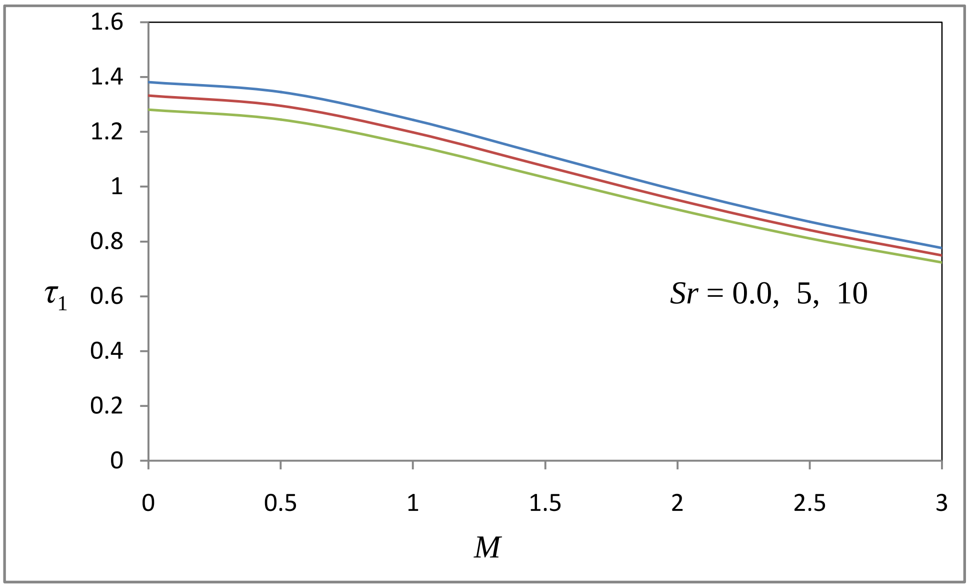


Figure 13: Skin friction τ_1 against *M*, under *Sr* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *N*=1, *Da*=1, *Gr*=1, *Cr*=1, *Q*=1, $\omega=1,\ \lambda=1,\ \gamma=1,\ t=0.$

The effect of Soret number (*Sr*) on the skin friction (τ_0) and (τ_1) at the walls y=0 and y=1 respectively are presented in the figures 12 and 13. In these figures we see that $|\tau_0|$ and $|\tau_1|$ decreases as Soret number increases. In other words the internal friction due to viscosity on the either plates gets decreased under the effect of thermal diffusion.

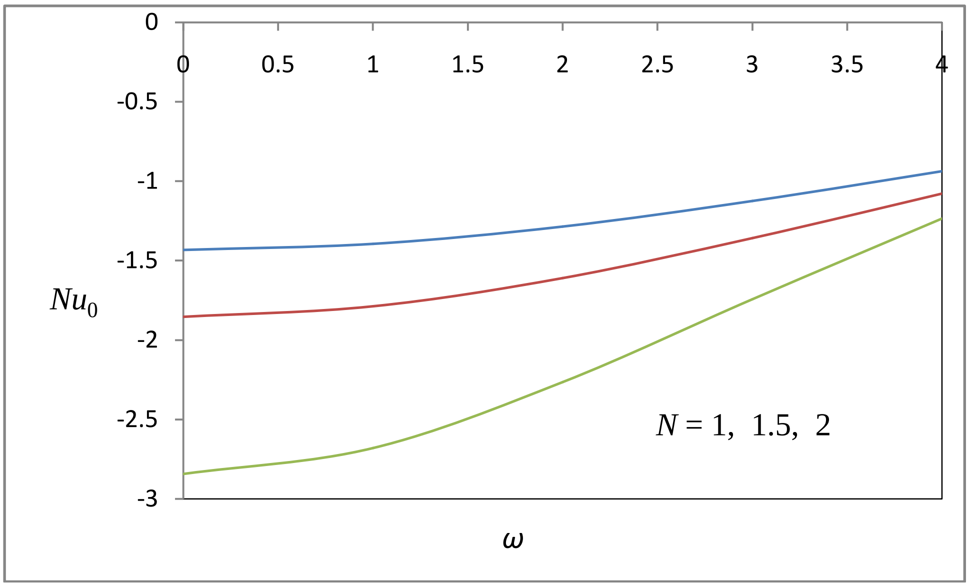


Figure 14: Nusselt number Nu_0 against ω, under *N* for *Pe*=0.71, *Gm*=1, *Re*=1, *Sc*=0.2, *Q*=1, *Da*=1, *Gr*=1, *Cr*=1, *M*=1, *Sr*=1, $\lambda=1,\ \gamma=1,\ t=0.$

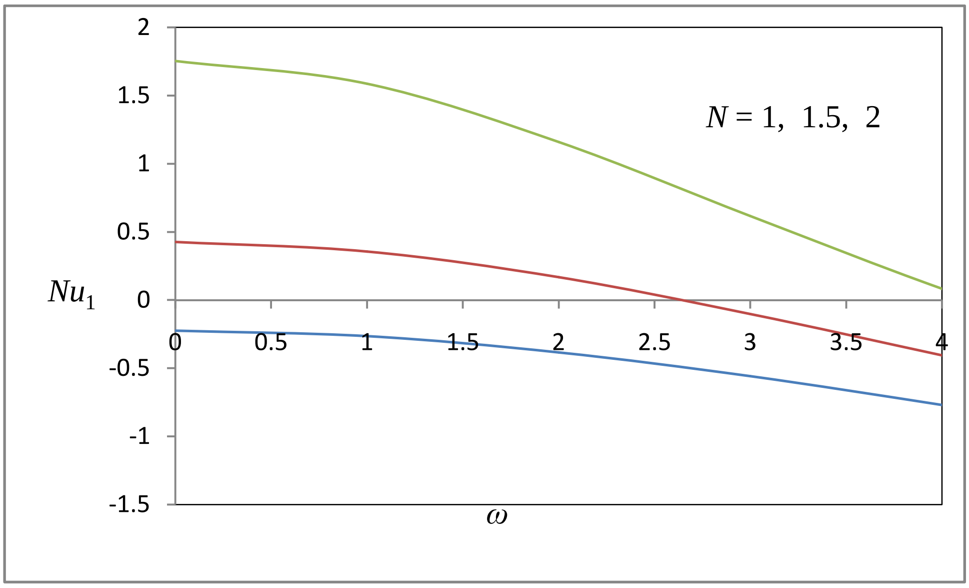


Figure 15: Nusselt number Nu_1 against ω, under N for Pe=0.71, Gm=1, Re=1, Sc=0.2, Q=1, Da=1, Gr=1, Cr=1, M=1, Sr=1, $\lambda = 1,\ \gamma = 1,\ t = 0.$

The influence of the radiation on the Nusselt numbers as illustrated in Figures 14 and 15. It is observed that the magnitude of the Nusselt numbers $|Nu_0|$ and $|Nu_1|$ increases with radiation. This establishes the fact that the rate of heat transfer from the plate to the fluid rises under the radiation effect.

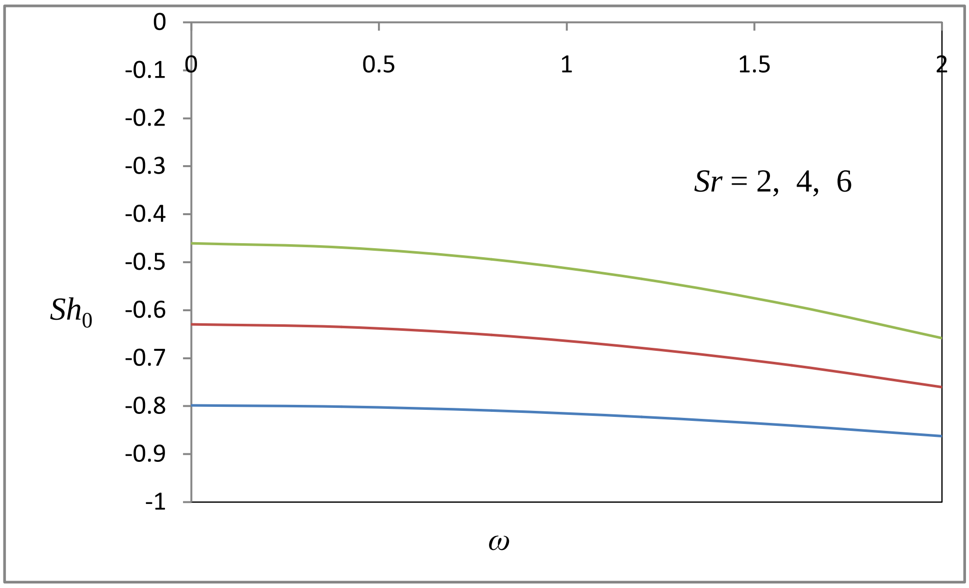


Figure 16: Sherwood number Sh_0 against ω, under Sr for Pe=0.71, Gm=1, Re=1, Sc=0.2, M=1, N=1, Da=1, Gr=1, Cr=1, Q=1, $\lambda = 1,\ \gamma = 1,\ t = 0.$

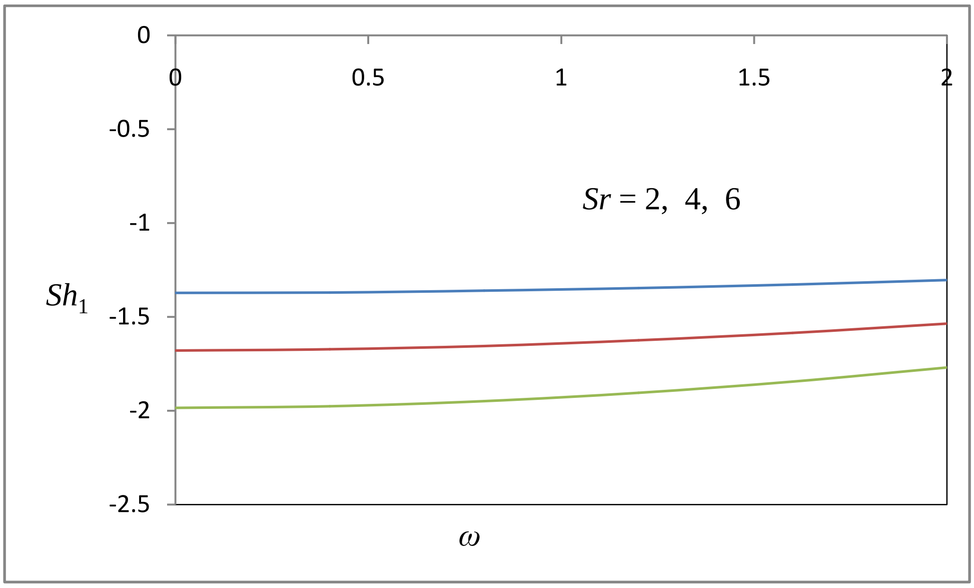


Figure 17: Sherwood number Sh_1 against ω, under Sr for Pe=0.71, Gm=1, Re=1, Sc=0.2, M=1, N=1, Da=1, Gr=1, Cr=1, Q=1, $\lambda = 1$, $\gamma = 1$, $t = 0$.

The figure 16 depicts how the Soret number (*Sr*) influences the Sherwood number on the plate y=0. This figure prevails that the magnitude of the rate of mass transfer from the plate is reduced under the effect of thermal diffusion. But the reverse trends of behaviour is observed at y=1 in Figure 17.

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. Results can be presented in figures, graphs, tables and others that make the reader understand easily [2], [5]. The discussion can be made in several sub-chapters.

3.1. Sub section 1

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3.2. Sub section2

Sub section should be written without bold type. The result and analysis are presented by present form. Please avoid too many paragraph in this section.

4. Conclusion

For the present transport model under the investigation, we arrive at the following conclusions.

- The fluid velocity rises with the increase in slip parameter, Solutal Grashof number or heat source parameter.
- The flow is decelerated with the increase in Schmidt number, Hartmann number or Soret number.
- The fluid temperature rises with the increase in heat source parameter and radiation parameter.
- The concentration level drops with the increase in Soret number and chemical reaction parameter.
- The magnitude of the skin frictions at the plate y=0 and y=1 decreases with the increase in Soret number
- The magnitude of the rate of heat transfer on the plates y=0 and y=1 increases with the increasing values of the radiation parameter.
- The magnitude of the rate of mass transfer from the plate to the fluid gets decreased under the influence of thermal diffusion on the plate y=0. But the reverse trends of behaviour is observed at y=1.

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APPENDIX

$$m_1=\sqrt{N^2+Q-i\omega Pe}\,,\quad m_2=\sqrt{(Cr+i\omega)ScRe}\,,\quad m_3=\sqrt{s^2+M^2+i\omega Re}\,,$$

$$C_1=-\frac{\lambda}{m_3^2}+\gamma\left[C_2m_3+\frac{Gr}{\left(m_1^2+m_3^2\right)}\frac{m_1}{\sin(m_1)}-\frac{Gm(1+A)}{\left(m_2^2-m_3^2\right)}\frac{m_2}{\sinh(m_2)}-\frac{GmA}{m_1^2+m_3^2}\frac{m_1}{\sin(m_1)}\right]$$

$$C_2 = \frac{1}{\{\sinh(m_3) + \gamma m_3 \cosh(m_3)\}} \begin{bmatrix} \frac{\lambda}{m_3^2}\{\cosh(m_3) - 1\} - \frac{Gr}{\left(m_1^2 + m_3^2\right)}\left\{1 + \frac{\gamma m_1 \cosh(m_3)}{\sin(m_1)}\right\} \\ + \frac{Gm(1+A)}{\left(m_2^2 - m_3^2\right)}\left\{1 + \frac{\gamma m_2 \cosh(m_3)}{\sinh(m_2)}\right\} \\ + \frac{GmA}{m_1^2 + m_3^2}\left\{1 + \frac{\gamma m_1 \cosh(m_3)}{\sin(m_1)}\right\} \end{bmatrix}$$

$$A = \frac{m_1^2 Sc Sr}{m_1^2 + m_2^2}$$

Nomenclature

a distance between two walls	Re Reynolds number
B_0 electromagnetic induction	s porous medium shape factor
$\overline{C}$ concentration	Sc Schmidt number
$\overline{C}_0$ concentration at $\overline{y} = 0$	Sr Soret number
$\overline{C}_w$ concentration at $\overline{y} = a$	$\overline{t}$ the time
$\overline{C}_r$ rate of first order homogeneous chemical reaction	t non-dimensional time
C_r non dimensional chemical reaction parameter	$\overline{T}$ fluid temperature
C_p specific heat at constant pressure	T dimensionless fluid temperature
D mass diffusion coefficient	$\overline{T}_0$ temperature at $\overline{y} = 0$
Da Darcy number	$\overline{T}_w$ temperature at $\overline{y} = a$
D_T thermal diffusion coefficient	$\overline{u}$ the axial velocity
g gravitational acceleration	u dimensionless axial velocity
Gm solutal Grashof number	U some reference velocity
Gr Thermal Grashof number	$(\overline{x}, \overline{y})$ the coordinate system
H_0 intensity of the magnetic field	(x, y) non-dimensional coordinate system
$\overline{K}$ permeability of the medium	α mean radiation absorption coefficient
K permeability parameter	β coefficient of volume expansion for heat transfer
M Hartmann number	coefficient of volume expansion for mass transfer
N radiation parameter	υ kinematic viscosity
$\overline{p}$ pressure	λ amplitude of the pressure gradient
p non-dimensional pressure	μ_e magnetic permeability
Pe Peclet number	σ electrical conductivity
Q_0 heat source parameter	$\overline{\gamma}$ slip parameter
Q dimensionless heat source parameter	γ dimensionless slip parameter
q_r the radiative heat flux	ρ fluid density
	κ thermal conductivity
	ω frequency parameter
	θ non-dimensional temperature
	ϕ non-dimensional concentration