Influence of Heat Transfer on MHD Oscillatory Flow for Eyring-Powell Fluid through a Porous Medium with Varying Temperature and Concentration

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Abstract
The aim of this research is to study the effect of heat transfer on the oscillating flow of the hydrodynamics magnetizing Eyring-Powell fluid through a porous medium under the influence of temperature and concentration for two types of engineering conditions "Poiseuille flow and Couette flow". We used the perturbation method to obtain a clear formula for fluid motion. The results obtained are illustrated by graphs.

Keywords: Eyring-Powell fluid, MHD, Oscillatory flow, Porous medium.

Introduction
Many researchers have been interested in the analysis of non–Newtonian fluids during the past few decades. The main concept behind MHD is that magnetic fields can stimulate currents in a moving conductive fluid which in turn polarizes the fluid and similarly changes the magnetic field itself. MHD plays an important role in different areas of science and technology. Nigamf and Singhj [1] studied the flow between parallel plates under the influence of the transverse magnetic field and heat transfer. Raptis et al. [2] studied the hydro-magnetic free convection flow through a porous medium between two parallel plates. Hamza et al. [3] discussed the effects of the slipping state as well as the transverse magnetic field and the radiative heat transfer for the unstable flow of a thin fluid. Khudair and Al-khafaji [4] discussed the effect of heat-transfer on MHD oscillatory flow for Williamson fluid through the porous medium. Migtaa and Al-khafaji discussed the effect of heat transfer on the MHD oscillatory flow of Carreau-Yasuda fluid through a porous medium [5]. Hayat and Abdulhadi [6] discussed the peristaltic transport of MHD Eyring-Powell fluid through porous medium in a three-dimensional domain.
dimensional rectangular duct. Hussain et al. analyzed the MHD flow of Powell-Eyring fluid by a stretching cylinder with Newtonian heating [7]. Begam and Deivanayaki studied the pulsatile flow of Eyring-powell nanofluid with Hall effect through a porous medium in [8]. More details about this topic are provided elsewhere [9-17].

Recently, a group of researchers described the effects of temperature and concentration on fluid movement. Most of these investigations agreed that the increase in temperature increases the velocity of the fluid while the fluid velocity changes in an unclear manner with the difference in concentration and according to the location of the fluid in the channel [16-21].

The present analysis aims to discuss the effects of heat transfer on the oscillating flow of the hydrodynamics of magnetizing Eyring-Power fluid through a porous medium under the influence of temperature and concentration for two types of engineering flows "Poiseuille flow and Couette flow". To our knowledge, this attempt has not yet been explored.

This paper consists of six sections; section 1, which is the introduction, provides a historical overview of the studies that dealt with this topic. Section 2 includes the form of the flow channel with the formulation of the governing equations with boundaries conditions and the formula of the Eyring-Powell fluid equation. In section 3, we review the dimensionless transformations to formulate the governing equations in a way that helps in solving them. Section 4 includes problem-solving and finding the formula for temperature, concentration, and velocity for the two types of engineering flows. In sections 5 and 6, we discuss the results through illustrated graphs and review the most important observations that we reached.

2. Mathematical Formulation

Let us consider the flow of an Eyring-Powell fluid in a porous medium of width $h$ under the effects of the electrically applied magnetic field and radioactive heat transfer, as illustrated in Figure-1. Suppose that the fluid has very small electromagnetic force and the electrical conductivity is small. We are considering Cartesian coordinate system such that ($x, y, z$) is a velocity vector in which $u$ is the $x$-component of velocity and $y$ is perpendicular to the $x$-axis.

The basic equations governing Eyring – Powell fluid are given by:

The continuity equation is given by:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0.$$  

(1)

The momentum equations are:

In the $x$ – direction:

$$\rho \left( \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} \right) = \frac{\partial s_{xy}}{\partial x} + \frac{\partial s_{xy}}{\partial y} + \rho g \beta T (T - T_0) + \rho g \beta_C (C - C_0) - \sigma B_0^2 \sin^2(\xi) \bar{u} - \frac{\mu_0}{k} \bar{\nabla} \bar{u}. $$

(2)

In the $y$ – direction:

$$\rho \left( \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} \right) = \frac{\partial s_{xy}}{\partial x} + \frac{\partial s_{xy}}{\partial y} - \frac{\mu_0}{k} \bar{v}. $$

(3)

The temperature equation is given by:

$$\frac{\partial T}{\partial t} = \frac{K}{\rho C_p \frac{\partial^2 T}{\partial y^2}} - \frac{1}{\rho C_p} \frac{\partial q}{\partial y} + \frac{Q_H}{\rho C_p} (T - T_0). $$

(4)

The concentration equation is given by:

$$\frac{\partial C}{\partial t} = \frac{\partial^2 C}{\partial y^2} - K_R^{\gamma} (C - C_0) + \frac{\partial^2 T}{T_m \frac{\partial y^2}{\partial y^2}}. $$

(5)

where $\bar{u}$ is the axial velocity, $\rho$ is the density of the fluid, $p$ is the pressure, $\sigma$ is the electrical conductivity, $B_0$ is the strength of the magnetic field, and $g$ is the acceleration due to gravity. In the same equations, we can define $T$ as a temperature, $C_p$ is specific heat at constant pressure, $q$ is the radiation heat flux, and $K$ is thermal conductivity.
In addition, $Q_T$ is heat generation, $D$ is the coefficient of mass diffusivity, $(0 \leq \xi \leq \pi)$ is the angle between velocity field and magnetic field strength, and $K_T$ is the thermal diffusion ratio.

The corresponding boundary conditions are given below:

$$
\begin{align*}
\bar{u} &= 0 \text{ at } \bar{y} = 0 \text{ and } \bar{u} = 0 \text{ at } \bar{y} = 1 \text{ (for Poiseuille flow)} \\
\bar{u} &= 0 \text{ at } \bar{y} = 0 \text{ and } \bar{u} = U_0 \text{ at } \bar{y} = h \text{ (for Couette flow)} \\
T &= T_0, C = C_0 \text{ at } \bar{y} = 0 \text{ and } T = T_1, C = C_1 \text{ at } \bar{y} = h
\end{align*}
$$

subject to

$$
\frac{\partial \bar{u}}{\partial \bar{y}} = 4n^2 (T_0 - T),
$$

where $n$ is the radiation absorption.

The fundamental equation for Eyring–Powell fluid is given by:

$$
\bar{p} = \frac{\mu_0}{\mu_0^*}, \bar{p} = \bar{T} = \bar{V} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \bar{v} = \bar{u} = \frac{1}{\bar{B}_1} \sinh^{-1} \left( \frac{1}{\bar{A}_1} \bar{V} \right),
$$

where $\bar{p}$ is the pressure, $I$ is the unit tensor, $\bar{\tau}$ is the extra stress tensor, $\mu_0$ is the zero shear rate viscosity, and $\bar{V}$ is the velocity gradient. We can write the component of extra stress tensor as follows:

$$
\bar{\tau}_{xx} = \bar{\tau}_{yy} = \bar{\tau}_{yy} = 0, \quad \bar{\tau}_{xy} = \left( \mu_0 + \frac{1}{\bar{B}_1 A_1} \frac{\partial \bar{u}}{\partial \bar{y}} - \frac{1}{6 \bar{B}_1 A_1^2} \left( \frac{\partial \bar{u}}{\partial \bar{y}} \right)^3 \right).
$$

3. Method of Solution

The non-dimensional governing equations are given by:

$$
\begin{align*}
x &= \frac{\bar{x}}{h}, y &= \frac{\bar{y}}{h}, u &= \frac{\bar{u}}{u}, \quad p = \frac{\bar{p}}{\mu_0^*}, \quad Pe = \frac{\bar{p} \bar{u} c_p}{K}, \quad t = \frac{\bar{t}}{h}, \quad \bar{K} = \frac{h}{K} \\
R &= \frac{4n^2 h^2}{K}, \quad \bar{A} = \frac{\bar{A}_1}{h}, \quad \bar{B} = \frac{\bar{B}_1}{h}, \quad \bar{D} = \frac{\bar{D}_1}{h}, \quad \bar{E} = \frac{\bar{E}_1}{h}, \quad \bar{F} = \frac{\bar{F}_1}{h}
\end{align*}
$$

subject to

$$
\begin{align*}
\bar{u} &= 0 \text{ on } \bar{y} = 0, \quad \bar{p} = \bar{K} \bar{u} \text{ on } \bar{y} = 1 \\
\bar{u} &= 0 \text{ at } \bar{y} = 0, \quad \bar{u} = U_0 \text{ at } \bar{y} = 1 \\
\bar{T} &= T_0 \text{ at } \bar{y} = 0, \quad \bar{T} = T_1 \text{ at } \bar{y} = 1
\end{align*}
$$

where $\bar{u}$ is the mean flow velocity, $Da$ is the Darcy number, $Pe$ is the Peclet number, $Re$ is the Reynolds number, $M$ is the magnetic parameter, $A$ is the mean temperature, $Gr$ is the Grashof number, and $Sc$ is the Soret number.

Substituting equations (7) - (9) into equations (1) - (6) yields the following non-dimensional equations:

$$
\begin{align*}
\frac{\partial \bar{u}}{\partial \bar{x}} + \frac{\partial \bar{v}}{\partial \bar{y}} &= 0, \\
\frac{\partial \bar{u}}{\partial \bar{t}} &= -\frac{\partial \bar{p}}{\partial \bar{x}} + \frac{\partial^2 \bar{r}_{xy}}{\partial \bar{y}^2} + Gr \bar{\theta} + Gc \Phi - \left( M_2^2 + \frac{1}{Da} \right) \bar{u}, \\
\frac{\partial \bar{p}}{\partial \bar{t}} &= 0, \\
\frac{\partial \bar{\theta}}{\partial \bar{t}} &= \frac{\partial^2 \bar{\theta}}{\partial \bar{y}^2} + (R + Q) \bar{\theta}, \\
\frac{\partial \Phi}{\partial \bar{t}} &= \frac{1}{Sc} \frac{\partial^2 \Phi}{\partial \bar{y}^2} - Kr \Phi + Sr \frac{\partial^2 \bar{\theta}}{\partial \bar{y}^2}, \\
\bar{\tau}_{xy} &= (1 + W_1) \frac{\partial \bar{u}}{\partial \bar{y}} - A \left( \frac{\partial \bar{u}}{\partial \bar{y}} \right)^3.
\end{align*}
$$

4. Solution of the Problem

This section contains the solution to the governing equations that is related to the above equations.

4.1. Solution of the Heat and Concentration Equations

To achieve this solution, we use the separating variables method, by assuming that $\bar{\theta}(y, t) =$
\[ e^{i\omega t} \theta_0(y) \] for heat equation (13) and \[ \Phi(y, t) = e^{i\omega t} \Phi_0(y) \] for the concentration equation (15), where \( \omega \) is the frequency of oscillation with the boundary condition (18) \[ (21) \]. As a result, we obtain the heat equation solution as follows:

\[ \theta(y, t) = \csc(Z) \sin(Zy) e^{i\omega t}, \]

where \( Z = \sqrt{R + Q - i\omega Pe} \).

The concentration equation solution is achieved by:

\[ \Phi(y, t) = \left( \frac{G e^{(Z^2+G^2) \sin(Zy)}}{(Z^2+G^2)} \right) e^{i\omega t}, \]

where \( G = \sqrt{Sc(Kr + i\omega)} \).

4.2. Solution of the Motion Equation

To solve the motion equation for two flows which are “Poiseuille flow and Couette flow”, let

\[ \frac{dp}{dx} = -\lambda e^{i\omega t}, \quad u(y, t) = u_1(y)e^{i\omega t}. \]

where \( \lambda \) is a real constant and \( \omega \) is the frequency of the oscillation.

By substituting equation (22) into equation (19) then simplifying the result we get:

\[ 3\lambda e^{2i\omega t} \left( \frac{\partial}{\partial y} u_{10} + \frac{1}{1+W_1} \frac{\partial}{\partial y} \right) - (1 + W_1) \left( \frac{\partial^2 u_{10}}{\partial y^2} \right) = \left( \frac{1}{1+W_1} \right) \left( \frac{\partial}{\partial y} \right)^2 u_{10} + \frac{i\omega Re u_1}{1+W_1} = \lambda + Gr\theta_0 + Gc\Phi_0. \]

4.2.1 Poiseuille flow

We employ the solution of equation (25) for Poiseuille flow by using boundary condition (16) to solve the zero and first orders system.

**I - Zero-order system** \( (A^0) \)

\[ \frac{\partial^2 u_{10}}{\partial y^2} - \left( \frac{M_2^2 + 1}{Da} + i\omega Re \right) u_{10} = - \left( \frac{1}{1+W_1} \right) \left( \frac{\partial}{\partial y} \right)^2 u_{10}, \]

with boundary conditions \( u_{10}(0) = u_{10}(1) = 0 \).

**II - First-order system** \( (A^1) \)

\[ \frac{\partial^2 u_{11}}{\partial y^2} - \left( \frac{M_2^2 + 1}{Da} + i\omega Re \right) u_{11} = \left( \frac{1}{1+W_1} \right) \left( \frac{\partial}{\partial y} \right)^2 u_{10} \]

with boundary condition \( u_{11}(0) = u_{11}(1) = 0 \).

**III - Zero-order solution**

The solution of the zero-order equation subject to the associate boundary conditions is:

\[ u_{10} = \frac{G}{2} + e^{y\sqrt{F}} \left( -\frac{G}{1+e^{y\sqrt{F}}} \right) + e^{-y\sqrt{F}} \left( -\frac{e^{y\sqrt{G}}}{1+e^{y\sqrt{G}}} \right). \]

**III - First - order solution**

The solution of the first-order equation subject to the associate boundary conditions is:

\[ u_{11} = 3e^{2i\omega t} - \left( \frac{1}{1+W_1} \right) \left( \frac{\partial}{\partial y} \right)^2 u_{10} \]

where \( F = ((M \sin[\xi] + i\omega Re + \frac{1}{Da})(1 + W_1)) \), \( G = ((\lambda + Gr\theta_0 + Gc\Phi_0)/(1 + W_1)) \).

Hence, the fluid velocity is given by:

\[ u(y, t) = (u_{10} + u_{11})e^{i\omega t}. \]

4.2.2 Couette flow

In this flow, the lower flake is fixed and the upper plate is moving with the velocity \( U_h \). The
boundary conditions for the Couette flow problem are defined as:

\( (0) = 0 \), \( (1) = U_0 \).

We simulate Couette flow by using the same previous method that we applied to solve Poiseuille flow in equation (25). The solution is calculated by the perturbation technique and the results are discussed with relevant figures.

5. Results and Discussion

We discuss the influence of heat transfer on MHD oscillatory flow for Eyring – Powell fluid through a porous medium with varying temperatures and concentrations for two types of engineering flows "Poiseuille flow and Couette flow" by using graphical illustrations. The temperature difference on both sides of the flow channel affects the fluid movement within the flow channel. The temperature difference depends on the parameters of \( R \), \( Q \), \( Pe \), and \( \omega \), as shown in the temperature charges. In equation (2) we notice the effects of different temperatures and concentrations, on both sides of the flow channel, on the fluid movement within the flow channel. We provide numerical assessments of analytical results and some of the graphically significant results that are presented in Figures-2-23. We used the MATHEMATICA-12 program to find numerical results and illustrations.

The velocity profile of the Poiseuille flow is shown in Figures-2-9. Figure-2 shows that velocity profile \( u \) decreases with increasing \( \omega \) and \( W_1 \). Figure-3 illustrates the influence of \( \xi \) and \( R \) on the velocity profiles \( u \) on the \( y \) axis. It is found that the velocity decreases with the increase of \( \xi \) while it increases with the increase of \( R \). As illustrated in Figure-4, the velocity profile \( u \) increases with the increase of \( Gr \) and \( Gc \), respectively, while it decreases with the increasing the parameters \( Sr \) and \( Sc \), as shown in Figure-5. Figure-6 illustrates the influence of \( \lambda \) and \( Kr \) on the velocity profiles function \( u \) on the \( y \) axis. It is found that by increasing \( \lambda \), the velocity increases, whereas it decreases with increasing \( Kr \). We found that the velocity increases with increasing \( Da \), \( Pe \), \( Re \) and \( Q \), as demonstrated in Figures-7 and 8, respectively. Figure-9 shows that the velocity increases with the increase of \( A \) and decreases with the increase of \( M \). The velocity profile of Couette flow is shown in Figures-(10-17). It is found that the velocity increases with increasing the parameters \( R \), \( Gr \), \( Gc \), \( \lambda \), \( Da \), \( Pe \), \( Re \), \( Q \), and \( A \), respectively, while the velocity decreases with the increase of \( \omega \), \( W_1 \), \( \xi \), \( Sr \), \( Sc \), \( Kr \) and \( M \).

Based on equation (20), Figures-(18-19) show that the temperature increases with the increase in \( R \), \( Q \) and \( Pe \), while it decreases with the increase in \( \omega \). Based on equation (21), the concentration decreases with the increase of all parameters, (Figures-20-23).

**Figure 2**-Poiseuille flow velocity profile for \( \omega \) and \( W_1 \) with \( A = 0.1 \), \( M = 1 \), \( Re = 2 \), \( Q = 2 \), \( Da = 0.8 \), \( \lambda = 1 \), \( Pe = 0.7 \), \( Sr = 0.2 \), \( Kr = 0.5 \), \( Sc = 0.6 \), \( Gr = 1 \), \( Gc = 1 \), \( \xi = \frac{\pi}{4} \), \( t = 0.5 \), \( R = 2 \).

**Figure 3**-Poiseuille flow velocity profile for \( \xi \) and \( R \) with \( \omega = 1 \), \( W_1 = 0.5 \), \( A = 0.1 \), \( M = 1 \), \( Re = 2 \), \( Q = 2 \), \( Da = 0.8 \), \( \lambda = 1 \), \( Pe = 0.7 \), \( Sr = 0.5 \), \( Kr = 0.5 \), \( Sc = 0.6 \), \( Gr = 1 \), \( Gc = 1 \), \( t = 0.5 \).
**Figure 4**-Poiseuille flow velocity profile for Gr and Gc with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Kr = 0.5, Sc = 0.6, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

**Figure 5**-Poiseuille flow velocity profile for Sr and Sc with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

**Figure 6**-Poiseuille flow velocity profile for $\lambda$ and Kr with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, Pe = 0.7, Sr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

**Figure 7**-Poiseuille flow velocity profile for Da and Pe with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, \lambda = 1, Kr = 0.5, Sr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.
Figure 8: Poiseuille flow velocity profile for Re and Q with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Sc = 0.6, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2.$

Figure 9: Poiseuille flow velocity profile for A and M with $\omega = 1, W_1 = 0.5, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Sc = 0.6, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2.$

Figure 10: Couette flow velocity profile for $\omega$ and $W_1$ with $A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Kr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2.$

Figure 11: Couette flow velocity profile for $\xi$ and R with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Kr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, t = 0.5.$
Figure 12—Couette flow velocity profile for $Gr$ and $Gc$ with $\omega = 1, W_1 = 0.5, \lambda = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Kr = 0.5, Sc = 0.6, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

Figure 13—Couette flow velocity profile for $Sr$ and $Sc$ with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

Figure 14—Couette flow velocity profile for $\lambda$ and $Kr$ with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, Da = 0.8, Pe = 0.7, Sr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

Figure 15—Couette flow velocity profile for $Da$ and $Pe$ with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 2, Q = 2, \lambda = 1, Kr = 0.5, Sr = 0.5, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$. 
**Figure 16** - Couette flow velocity profile for $Re$ and $Q$ with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.5, Sc = 0.6, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

**Figure 17** - Couette flow velocity profile for $A$ and $M$ with $\omega = 1, W_1 = 0.5, Re = 2, Q = 2, Da = 0.8, \lambda = 1, Pe = 0.7, Sr = 0.1, Sc = 0.6, Kr = 0.5, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, t = 0.5, R = 2$.

**Figure 12** - Couette flow velocity profile for $Da$ and $Pe$ with $\omega = 1, W_1 = 0.5, A = 0.1, M = 1, Re = 1, Q = 2, \lambda = 1, Kr = 0.5, Sr = 0.1, Sc = 0.6, Gr = 1, Gc = 1, \xi = \frac{\pi}{4}, U_0 = 0.3, t = 0.5, R = 2$.

**Figure 18** - Influence of $\omega$ and $Pe$ on temperature $\theta$ for $R = 2, Q = 2, t = 0.5$.

**Figure 19** - Influence of $R$ and $Q$ on temperature $\theta$ for $\omega = 1, Pe = 0.7, t = 0.5$.  

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Figure 20-Influence of $R$ and $Q$ on concentration for $\omega = 1, Pe = 0.7, 0.1, Kr = 0.5, Sc = 0.6, t = 0.5$.  

Figure 21 Influence of $\omega$ and $Pe$ on concentration for $R = 2, Q = 2, Sr = 0.1, Sr = Kr = 0.5, Sc = 0.6, t = 0.5$.  

Figure 22-Influence of $Sr$ and $Sc$ on concentration for $\omega = 1, R = 2, Q = 2, Pe = 0.7, Kr = 0.5, t = 0.5$.  

Figure 23-Influence of $\omega$ and $Kr$ on concentration for $R = 2, Q = 2, Pe = 0.7, Sr = 0.1, Sc = 0.6, t = 0.5$.  

6. Concluding Remarks  
We discuss the influence of heat transfer on MHD oscillatory flow for Eyring-Powell fluid through a porous medium with varying temperature and concentration. Using the perturbation technique, we analyzed the velocity, temperature and concentration. We used different values to find the results of pertinent parameters, namely Darcy number, Peclet number, Grashof number, magnetic parameter, radiation parameter, Schmidt number, Soret number, heat generation parameter, frequency of the oscillation, and Reynolds number. The key points are:  
• In the two types of flow, i.e. Poiseuille and Couette, the velocity increases with increasing the parameters $R$, $Gr$, $Ge$, $\lambda$, $Da$, $Pe$, $Re$, $Q$ and $A$, respectively, while the velocity decreases with increasing $\omega$, $W_1$, $t$, $Sr$, $Sc$, $Kr$ and $M$.  
• The temperature increases with the increase in $R$, $Q$ and $Pe$ while decreases with the increase in $\omega$.  
• The concentration decreases with the increase of all parameters.  

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