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MODELING OF MHD OSCILLATORY BLOOD FLOW IN A CHANNEL AS MICROPOLAR FLUID IN THE PRESENCE OF CHEMICAL REACTION

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ABSTRACT

MHD oscillatory blood flow in a channel as micropolar fluid in the presence of chemical reaction and a transverse magnetic field are studied. The partial differential equations governing the flow were formulated base on assumptions and already existing model. The partial differential equations were transformed to dimensionless equations with suitable variables. Analytical solution was obtained for the dimensionless equations. The pertinent parameters were investigated with graphs plotted and table generated using Matlab software. The study reveals that the parameters has significant influences on the flow.

Keywords: Blood, heat transfer, micropolar, oscillatory, porous medium, thermal radiation

INTRODUCTION

The process of using mathematical language to describes real life problems is known as mathematical modeling. The study of fluid dynamics plays significant role in fluid flowing inside human body and modeling of blood flow is important in cardiovascular system. Cardiovascular system is the blood distribution network that consists of blood, heart and blood vessels. There are three major types of blood vessels; arteries, capillaries and veins. Arteries are large blood vessels that carry blood away from the heart to all regions of the body (Ehrlich and Schroed, 2004). Blood flows from arteries to capillaries then into veins. It is electrically conducting fluid which contains ions that can be influenced by the presence of magnetic field. It is approximately four times more viscous than water and contains a complex mixture of ions, proteins, lipoproteins and cells. MHD can be defined as the study of dynamics of electrically conducting fluid under the influence of magnetic field and blood flow in human system can be considered as a biofluid dynamics problem. Micropolar fluid represent a category of fluid that are containing microelements and possessing internal microstructure. It is a fluid that support couple stresses and exhibit microrotational as well as microinertial effects. The theory of micropolar fluid was introduced by(Erigen, 1966) and in the theory, rigid particles contained in a small volume element can rotate about the center of the volume element. The rotation is described by an independent micro-rotation vector. A chemical reaction is the rearrangement of atoms of the reactants to create different substance as product. The chemicals and pollutants we inhale can end up in our blood stream and cause chemical reaction which the blood can carry to the rest of the body.

Many researchers has investigated work relating to modeling of MHD oscillatory blood flow in a channel as micropolar fluid in the presence of chemical reaction. (Abdullah and Norsarahaida, 2010) considered a non-linear two dimensional micropolar fluid model for blood flow in a tapered artery and the governing equations involving unsteady non-linear partial differential equations were solved using a finite difference scheme. Ahmad et al.(2020) investigated the micropolar fluid model of blood flow under the effect of body acceleration. The governing non-linear coupled partial differential equations were transformed and solved numerically by employing crank-Nicolson method with a suitable choice of initial and boundary conditions. (Sneha and Pramod, 2019) presented a two-phase model of blood flow through a porous layered artery in the presence of a uniform magnetic field and uses modified Bessel's function to obtain close form solution for analysis. (Moses and Funmilola, 2020) analyzed heat and mass transfer in micropolar fluid model for blood flow through a stenotic tapered artery using analytical solution. (Srinivsacharya and Srikanth, 2012) considered the flow of blood through catheterized artery with mild constriction at the outer wall and obtained close-form solution for the governing equations which was used to analyze the effects of various important parameter present in the flow. (Prasad and Yasa, 2021) studied micropolar fluid in tapering stenosed arteries having permeable walls using Homotopy perturbation method to obtain solution for analysis. Evangelos et al.(2020) investigated the effect of micropolar fluid properties on the blood flow in human carotid using 3D human carotid model that is computationally reconstructed.(Makinde and Mhone, 2005) studied the combined effects of transverse magnetic field and radiative heat transfer to unsteady oscillatory flow of a conducting optically thin fluid through a channel filled with porous medium. Analytical solution was obtained for the resulted dimensionless governing equations which was used to analyze the effects of the important parameter in the flow.(Misra and Adhikary, 2016) investigated MHD oscillatory channel flow of physiological fluid in the presence of chemical reaction. Ratchagar et al.(2018) analyzed the impart of Hall current in the transport phenomenon of MHD oscillatory channel of blood flow in the presence of chemical reaction and external magnetic field. We extend the work of (Makinde and Mbone,2005) by incorporating microrotational equation, concentration equation and using values of parameters according to (Misra and Adhihary, 2016) and Rtchagar et al.(2018) to study modeling of MHD oscillatory blood flow in a channel as micropolar fluid in the presence of chemical reaction which has not be done to the best of our knowledge.

Mathematical Formulation

Consider optically thin oscillatory blood flow in a channel filled with porous medium in the presence of chemical reaction as micropolar fluid under the influence of transverse magnetic field. It is assumed that the fluid has small electrical conductivity and the electromagnetic force produce is very small. The x-axis is taken along the centre of the channel and y- axis is taken to be normal to it as demonstrated in figure 1.

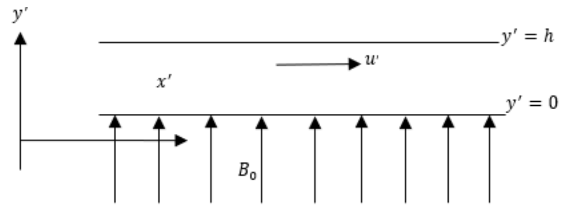

Figure 1: Blood flow in a channel.

Assuming Boussineq incompressible fluid model and extending the work of Makinde and Mhone[10], the linear momentum, angular momentum, energy and concentration equations governing the flow in the channel are

$$\frac{\partial u'}{\partial t'} = -\frac{1}{\rho}\frac{\partial \rho'}{\partial x'} + (v+v_r)\frac{\partial^2 u'}{\partial y'^2} - \frac{(v+v_r)}{K}u' + 2v_r\frac{\partial w'}{\partial y'} - \frac{\sigma B_0^2}{\rho}u' + gB_t,(T-T_0) + gB_C,(C-C_0) \quad (1)$$

$$\rho j\frac{\partial w'}{\partial t'} = \gamma\frac{\partial^2 w'}{\partial y'^2} \quad (2)$$

$$\frac{\partial T}{\partial t'} = \frac{k}{\rho c_p}\frac{\partial^2 T}{\partial y'^2} - \frac{1}{\rho c_p}\frac{\partial q_r}{\partial y\prime} \quad (3)$$

(3)

$$\frac{\partial C}{\partial t'} = D\frac{\partial^2 C'}{\partial y'^2} - K_c(C - C_o) \quad (4)$$

With the boundary condition:

$$u' = 0,\ w' = -n_1\frac{\partial u'}{\partial y'}T = T_0 + (T_w - T_0)e^{in't'}, C = C_0 + (C_w - C_0)e^{in't'}\ at\ y = h \quad (5)$$

$$u' = 0, w' = 0, T = T_0, C = C_0, at\ y' = 0 \quad (6)$$

Where u' is the translational velocity, w' is microrotational velocity, $(x'\ y')$ is the space co-ordinates, t' is time, n' is frequency of oscillation, T is the temperature of fluid, C is the concentration of the fluid ρ is the fluid density, p' is the pressure, g is gravitational force , v_r is rotational viscosity, v is kinematic viscosity, K is the permeability of the porous medium, σ is the conductivity of the medium. $B_0 = (\mu_e, H_o)$ is the electromagnetic induction where μ_e is the magnetic permeability and H_o is the intensity of magnetic field, B_t is the coefficient of volumetric thermal expansion, B_c is the coefficient of volumetric thermo expansion, j is the microinertia per unit mass,γ is the spin gradient viscosity, k is the thermal conductivity, C_p is the specific heat at constant pressure, K_c is the rate of chemical reaction, D is the molecular diffusivity , q_r is the radiative heat flux, T_w , $T_0, C_w, C_0\ and\ h$ are temperature at wall, temperature far from wall, concentration at wall, concentration far from wall and distant between the walls respectively. n_1 is the parameter that relates microgyration vector to shear stress, it is $0 \le n_1 \le 1$. When $n_1 = 0$, it represent the case of microelement unable to rotate. As $n_1 = 0.5$ and $n_1 = 1$, the microrotation gets augmented and induces flow enhancement. Following Cogley et al [13], for optically thin fluid with low density, radiative heat flux is given by

$$\frac{\partial q_r}{\partial y\prime} = 4\alpha^2(T_0 - T) \quad (7)$$

where α is the mean radiation absorption coefficient

Then equation (3) becomes

$$\frac{\partial T}{\partial t'} = \frac{k}{\rho c_p}\frac{\partial^2 T}{\partial y'^2} - \frac{1}{\rho c_p}4\alpha^2(T_0 - T) \quad (8)$$

Let us introduce the following non-dimensional variables for transformation;

$$y = \frac{y'}{h}, x = \frac{x'}{h}, u = \frac{u'}{U}, w = \frac{w'h}{U}, t = \frac{t'U}{h}, p = \frac{hp'}{\rho v U}, \theta = \frac{T-T_0}{T_w-T_0}, \emptyset = \frac{C-C_0}{C_w-C_0}, n = \frac{n'h}{U}, \quad (9)$$

Applying equation (8) for transformation, we now have the following dimensionless equation.

$$R_e\frac{\partial u}{\partial t} = \frac{-\partial p}{\partial x} + (1+\mathrm{r})\frac{\partial^2 u}{\partial y^2} - \{(1+r)S^2 + H^2\}u + 2r\frac{\partial w}{\partial y} + Gr\theta + Gc\emptyset \quad (10)$$

$$ma\frac{\partial w}{\partial t} = \frac{\partial^2 w}{\partial y^2} \quad (11)$$

$$P_e\frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2} + R^2\theta \quad (12)$$

$$Sc\frac{\partial \emptyset}{\partial t} = \frac{\partial^2 \emptyset}{\partial y^2} - \mathrm{Cr}\emptyset \quad (13)$$

With the dimensionless boundary conditions:

$$u = 0, w = -n_1\frac{\partial u}{\partial y}, \theta = e^{int}, \emptyset = e^{int}\ at\ y = 1 \quad (14)$$

$$u = 0\ , \theta = 0, \emptyset = 0, w = 0\ at\ y = 0 \quad (15)$$

Wher $R_e = \frac{Uh}{v}, r = \frac{v_r}{v}, S^2 = \frac{1}{Da}, Da = \frac{K}{h^2}\ H^2 = \frac{\sigma B_0^2 h^2}{\rho v}, G_r = \frac{gB_t(T_w-T_0)h^2}{vU}, G_c = \frac{gB_c(C_w-C_0)h^2}{vU}$, $ma = \frac{\alpha\rho j}{\gamma}$, $\mathrm{Pe} = \frac{Uh\rho C_p}{k}$, $R^2 = \frac{4\alpha^2 h^2}{k}, Sc = \frac{Uh}{D}\ and\ Cr = \frac{h^2 K_c}{D}$ are Renolds number(Re), viscosity ratio parameter(r), porous medium shape parameter (S) , Darcy number (Da) , Hartmann number (H) , Grashof number (Gr) , modified Grashof number(Gc), material parameter (ma), peclet number(Pe), radiation parameter(R), Schmidt number(Sc) and chemical reaction parameter (Cr) respectively.

METHOD OF SOLUTION

In order to solve the dimensionless governing equations for purely oscillatory flow, let

$\frac{\partial P}{\partial x} = \mathrm{X}e^{int}$ (where X is a constant, Ratchagar et al. (12)) (16)

$$u(y,t) = u_0(y)e^{int} \quad (17)$$

$$w(y,t) = w_0(y)e^{int} \quad (18)$$

$$\theta(y,t) = \theta_0(y)e^{int} \quad (19)$$

$$\emptyset(y,t) = \emptyset_0(y)e^{int} \quad (20)$$

Substituting equation (16) – (20) into (10)-(15), yields

$$Pu_0''(y) - Qu_0(y) = -X - 2rw'_0(y) - G_r\theta_0(y) - G_c\emptyset_0(y) \quad (21)$$

$$w_0''(y) - inmaw_0(y) \quad (22)$$

$$\theta_0''(y) + V\theta_0(y) = 0 \quad (23)$$

$$\emptyset_0''(y) - W\emptyset_0(y) = 0 \quad (24)$$

With the boundary conditions;

$$u_0(y) = 0, w_0'(y) = -n_1 u_0', \theta_0(y) = 1,\ \emptyset_0(y) = 1\ at\ y = 1 \quad (25)$$

$$u_0(y) = 0, \theta_0(y) = 0, w_0(y) = 0,\ \emptyset_0(y) = 0\ \ at\ y = 0 \quad (26)$$

Where $P = (1+r), Q = inR_e + \{(1+r)S^2 - H^2\}$, $V = R^2 - inP_e$ and $W = Cr + inSc$

Solving (17)-(24) with (25) and (26), we have:

$$u(y,t) = (C_1e^{m5y} + C_2e^{m6y} + C_3 + C_4e^{m1y} + C_5e^{m2y} + C_6\sin(\sqrt{V}y) + C_7e^{m3y} + C_8e^{m4y})e^{int} \quad (27)$$

$$w(y,t) = (A_1e^{m1y} + A_2e^{m2y})e^{int} \quad (28)$$

$$\theta(y,t) = \frac{\sin(\sqrt{V}y)}{\sin(V)}e^{int} \quad (29)$$

$$\emptyset(y,t) = (B_1e^{m3y} + B_2e^{m4y})e^{int} \quad (30)$$

Where $m_1 = \sqrt{inma}$

$m_2 = -\sqrt{inma}$

$m_3 = \sqrt{Cr + inSc}$

$m_4 = -\sqrt{Cr + inSc}$

$m_5 = \sqrt{Q/_P}$

$m_6 = -\sqrt{Q/_P}$

$C_3 = \frac{X}{Q}$

$C_6 = \frac{Gr}{(PV+Q)\sin(\sqrt{V})}$

$B_1 = \frac{1}{(e^{m3} - e^{m4})}$

$$B_2 = -B_1$$
$$C_7 = \frac{-GcB_1}{Pm_3^2 - Q}$$
$$C_8 = \frac{-GcB_2}{Pm_4^2 - Q}$$

$$A = \{(Pm_1^2 - Q)(e^{m1} - e^{m2}) - 2rm_1^2 n_1 e^{m1}\}(e^{m5} - e^{m6}) - 2rm_1 n_1\{m_5 e^{m5} e^{m6} - m_5 e^{m5} e^{m1} - m_6 e^{m6} e^{m6} + m_6 e^{m6} e^{m1} - m_6 e^{m6}(e^{m5} - e^{m6})\}$$

$$B = -2rm_1 n_1\{m_2 e^{m2}(e^{m5} - e^{m6}) + m_5 e^{m5} e^{m6} - m_5 e^{m5} e^{m2} - m_6 e^{m6} e^{m6} + m_6 e^{m6} e^{m2} - m_6 e^{m6}(e^{m5} - e^{m6})\}$$

$$D = \{(Pm_2^2 - Q)(e^{m1} - e^{m2}) + 2rm_2^2 n_1 e^{m2}\}(e^{m5} - e^{m6}) + 2rm_2 n_1\{m_5 e^{m5} e^{m6} - m_5 e^{m5} e^{m2} - m_6 e^{m6} e^{m6} + m_6 e^{m6} e^{m2} - m_6 e^{m6}(e^{m5} - e^{m6})\}$$

$$E = 2rm_2 n_1\{m_1 e^{m1}(e^{m5} - e^{m6}) + m_5 e^{m5} e^{m6} - m_5 e^{m5} e^{m1} - m_6 e^{m6} e^{m6} + m_6 e^{m6} e^{m1} - m_6 e^{m6}(e^{m5} - e^{m6})\}$$

$$Z_1 = 2rm_1 n_1\{m_5 e^{m5}\left[\left(e^{m6}(C_3 + C_7 + C_8) - C_3 - (C_6 \sin(\sqrt{V}) + C_7 e^{m3} + C_8 e^{m4})\right] - m_6 e^{m6}\left[\left(e^{m6}(C_3 + C_7 + C_8) - C_3 - (C_6 \sin(\sqrt{V}) + C_7 e^{m3} + C_8 e^{m4})\right] + C_3(e^{m5} - e^{m6}) + C_7(e^{m5} - e^{m6}) + C_8(e^{m5} - e^{m6})\} + (e^{m5} - e^{m6})\sqrt{V} C_6 \cos(\sqrt{V}) + m_3 e^{m3} C_7 + m_4 C_8 e^{m4}\}$$

$$Z_2 = -2rm_2 n_1\{m_5 e^{m5}\left[\left(e^{m6}(C_3 + C_7 + C_8) - C_3 - (C_6 \sin(\sqrt{V}) + C_7 e^{m3} + C_8 e^{m4})\right] - m_6 e^{m6}\left[\left(e^{m6}(C_3 + C_7 + C_8) - C_3 - (C_6 \sin(\sqrt{V}) + C_7 e^{m3} + C_8 e^{m4})\right] + C_3(e^{m5} - e^{m6}) + C_7(e^{m5} - e^{m6}) + C_8(e^{m5} - e^{m6})\} + (e^{m5} - e^{m6})\sqrt{V} C_6 \cos(\sqrt{V}) + m_3 e^{m3} C_7 + m_4 C_8 e^{m4}\}$$

$$C_4 = \frac{Z_2 B - Z_1 D}{BE - DA}$$
$$C_5 = \frac{Z_1 - AC_4}{B}$$

$$C_1 = \frac{(C_3 + C_4 + C_5 + C_7 + C_8)e^{m6} - C_3 - (C_4 e^{m1} + C_5 e^{m2} + C_6 \sin(\sqrt{V}) + C_7 e^{m3} + C_8 e^{m4})}{e^{m5} - e^{m6}}$$
$$C_2 = -(C_1 + C_3 + C_4 + C_5 + C_7 + C_8)$$
$$A_1 = \frac{n1(m_5 C_1 e^{m5} + m_6 C_2 e^{m6} + m_1 C_4 e^{m1} + m_2 C_5 e^{m2} + \sqrt{V} C_6 \cos(\sqrt{V}) + m_3 C_8 e^{m3} + m_4 C_8 e^{m4})}{e^{m1} - e^{m2}}$$
$$A_2 = -A_1$$

Couple stress coefficient represent the stress the fluid undergoes as a result of coupling.

The couple stress coefficient across the channel at upper and lower walls are:

$$C_w = \frac{\partial W}{\partial y} = (m_1 A_1 e^{m1} + m_2 A_2 e^{m2})\, e^{int} \quad (at\ y = 1)$$
$$C_w = \frac{\partial W}{\partial y} = (m_1 A_1 + m_2 A_2)\, e^{int} \quad (at\ y = 0$$

The rate of heat transfer across the channel at the upper and lower walls are:

$$N_u = -\frac{\partial \theta}{\partial y} = -\frac{\sqrt{V}\cos(\sqrt{V})}{\sin(\sqrt{V})}\, e^{int} \quad (at\ y = 1)$$
$$N_u = -\frac{\partial \theta}{\partial y} = -\frac{\sqrt{V}}{\sin(\sqrt{V})}\, e^{int} \quad (at\ y = 0)$$

The rate of mass transfer across the channel at upper and lower walls are:

$$S_h = -\frac{\partial \phi}{\partial y} = -(m_3 B_1 e^{m3} + m_4 B_2 e^{m4})\, e^{int} \quad (at\ y = 1)$$
$$S_h = -\frac{\partial \phi}{\partial y} = (m_3 B_1 + m_4 B_2)\, e^{int} \quad (at\ y = 0$$

RESULTS AND DISCUSSION

We have formulated and provided analytical solution to modeling of MHD oscillatory blood flow in a channel as micropolar fluid in the presence of chemical reaction. Numerical evaluation of the analytical solution for the translational velocity, microrotational velocity, temperature and concentration across the channel for varied parameters including couple stress coefficient, Nuselt number and Sherwood number was carried out and the results are presented in graphical and tabular form. We have chosen $t = 0, Gr = Gc = 2, ma = 1\ and\ n = 1$ while other parameters are varied in accordance with reference[11] and reference[12]

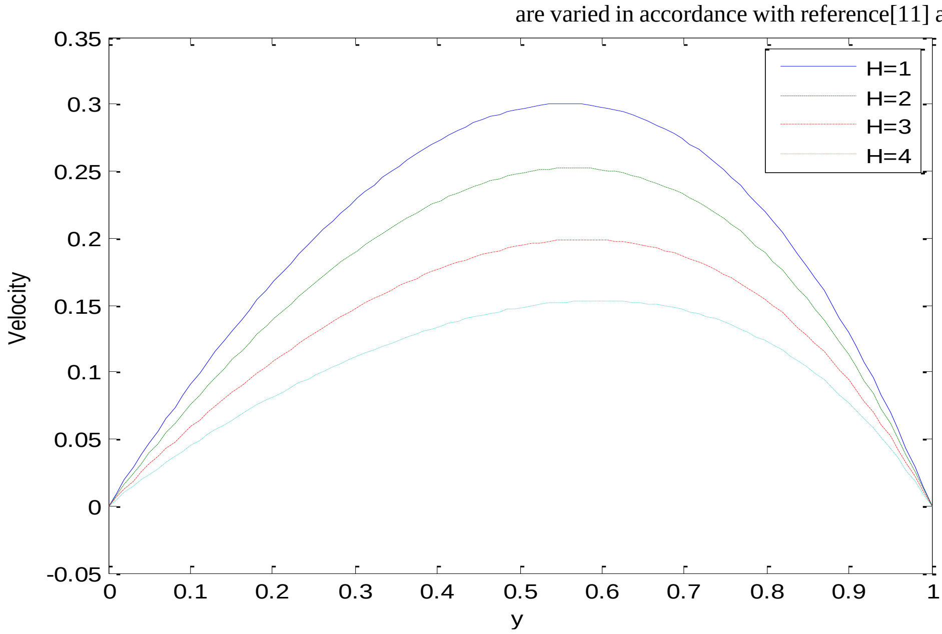

Figure 2: Velocity profiles for different values of Hartmann number.

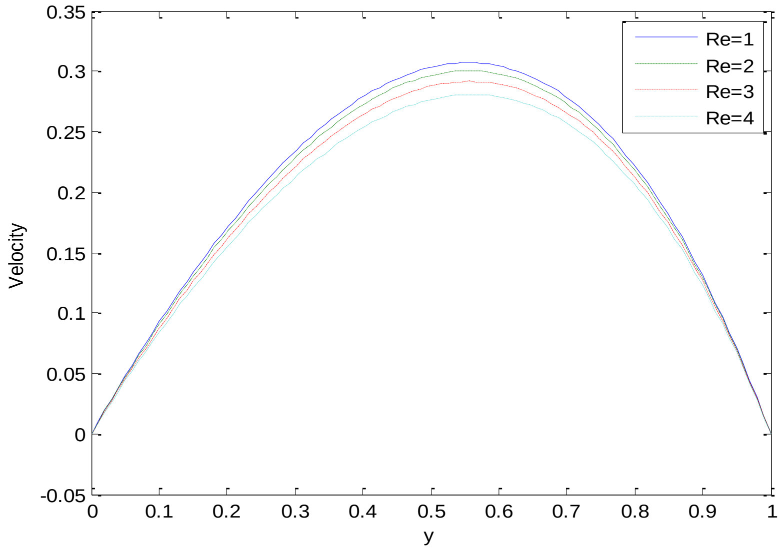

Figure 3: Velocity profiles for different values of Reynolds number.

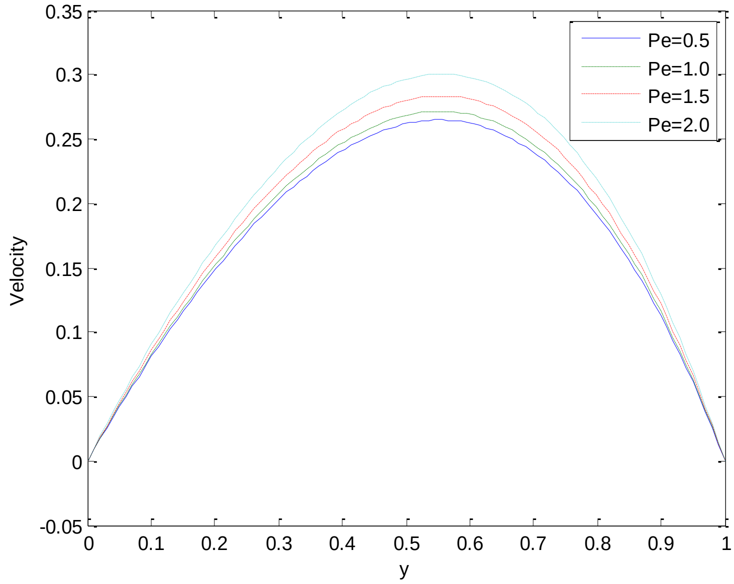

Figure 4: Velocity profiles for different values of peclet number

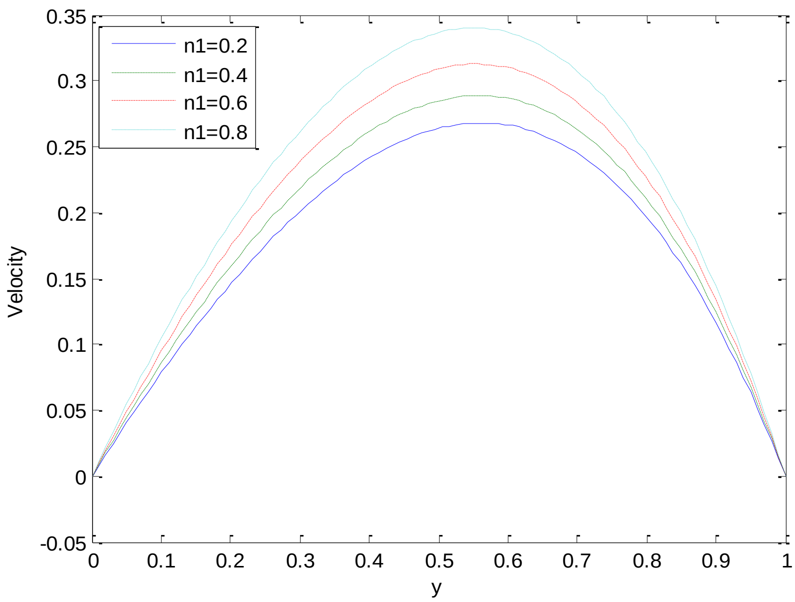

Figure 5: Velocity profiles for different values of parameter that relates microgyration vector to shear stress.

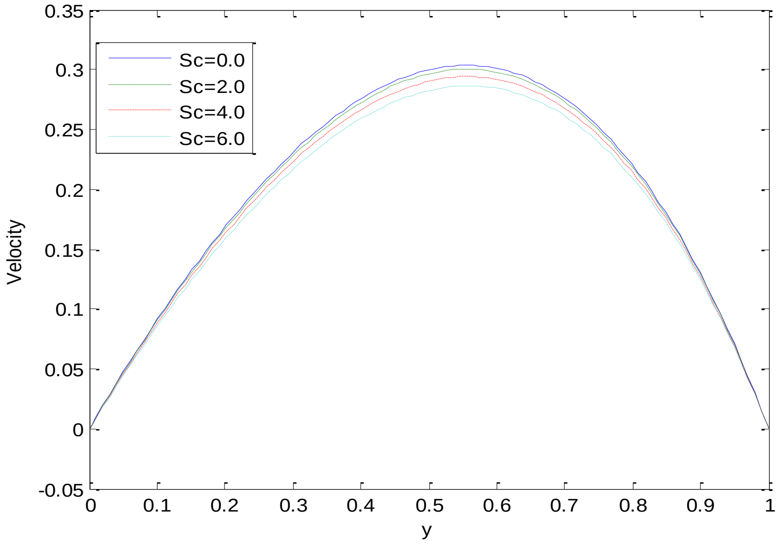

Figure 6: Velocity profiles for different values of Schmidt number

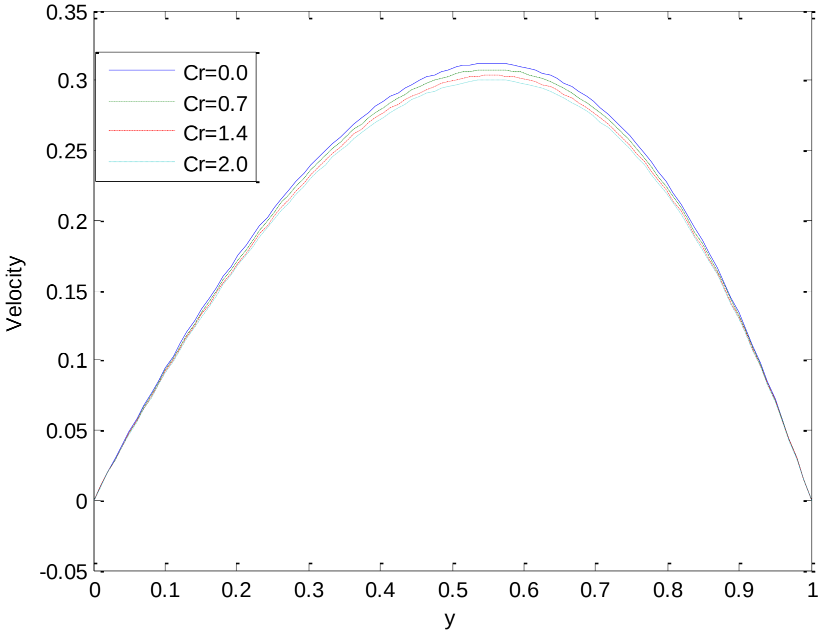

Figure 7: Velocity profiles for different values of chemical reaction parameter

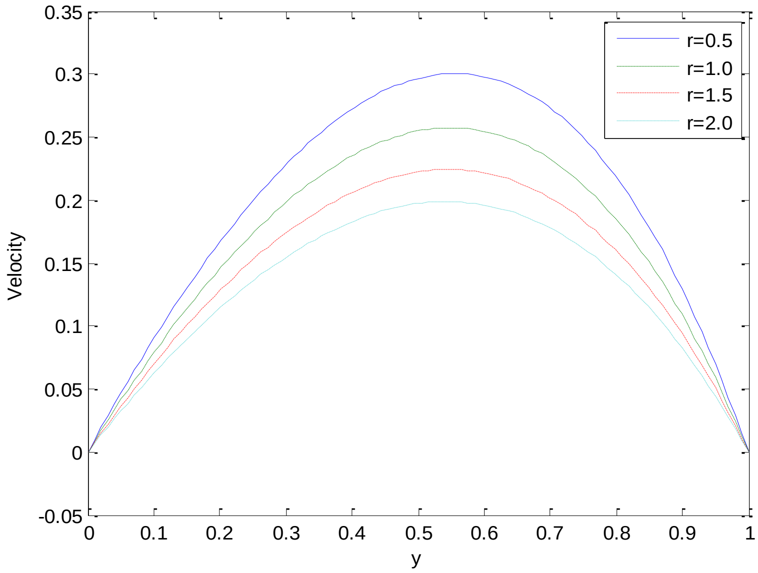

Figure 8:Velocity profiles for different values of viscosity ratio parameter

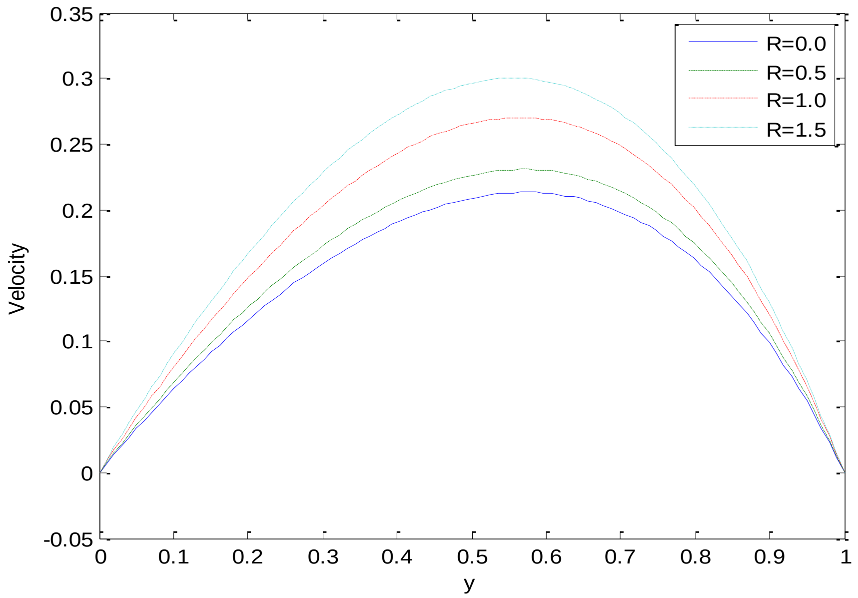

Figure 9: Velocity profiles for different values of radiation parameter

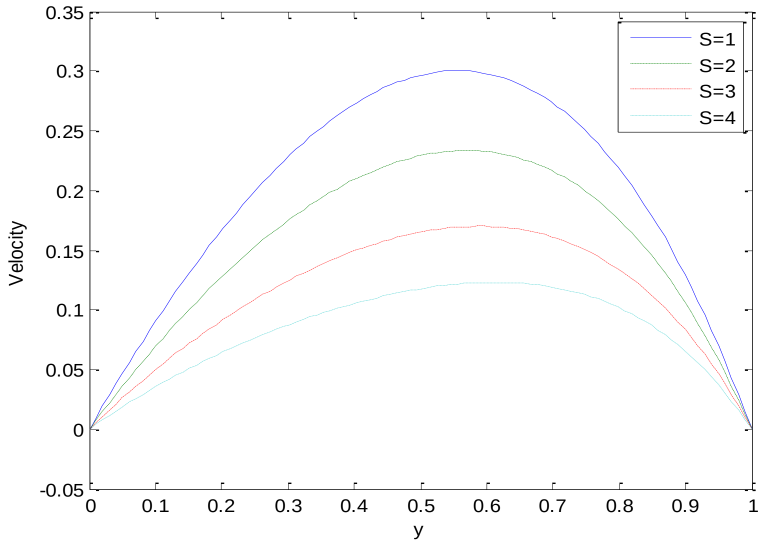

Figure 10: Velocity profiles for different values of porous medium shape parameter.

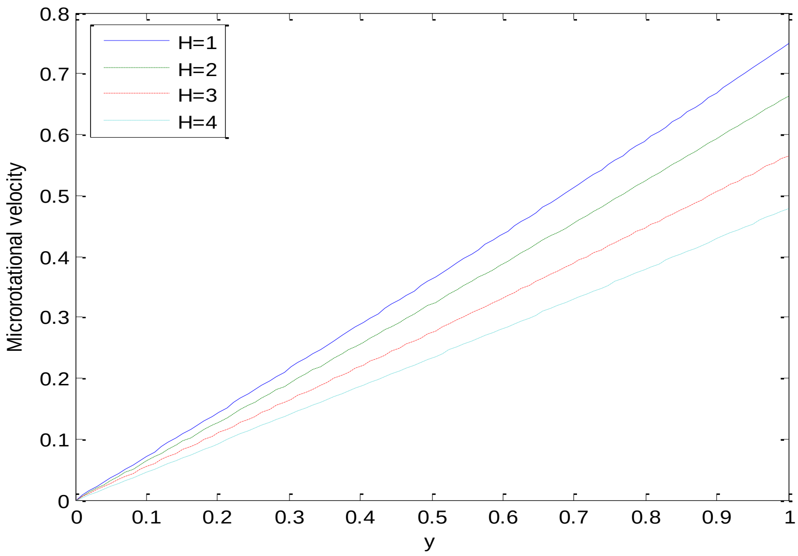

Figure 11: Microrotational velocity profiles for different values of Hartmann number

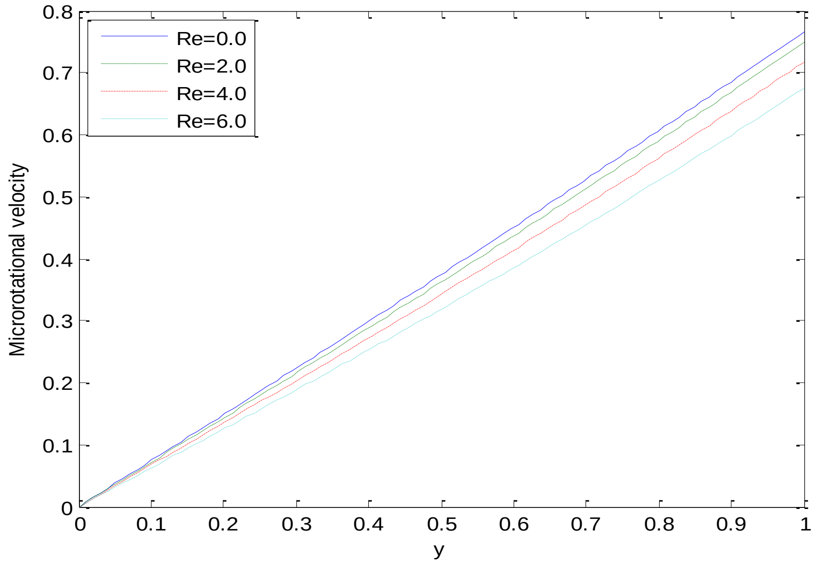

Figure 12: Microrotational velocity profiles for different values of Reynolds number.

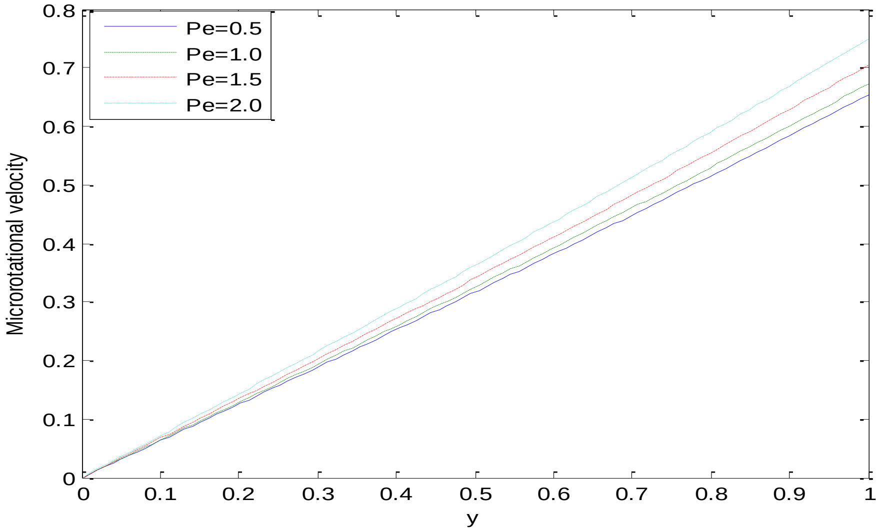

Figure 13: Microrotational velocity profiles for different values of Peclet number

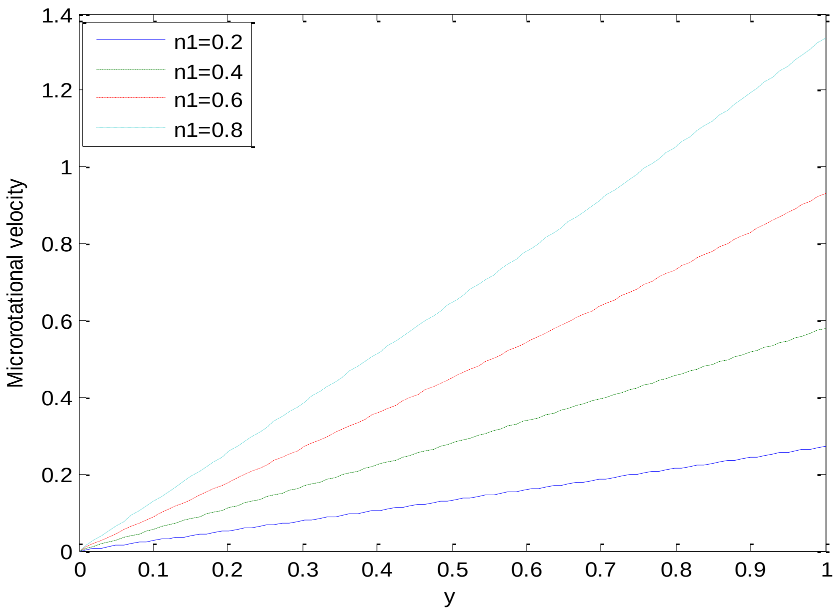

Figure 14: Microrotational velocity for different values of parameter that relates microgyration vector to shear sress

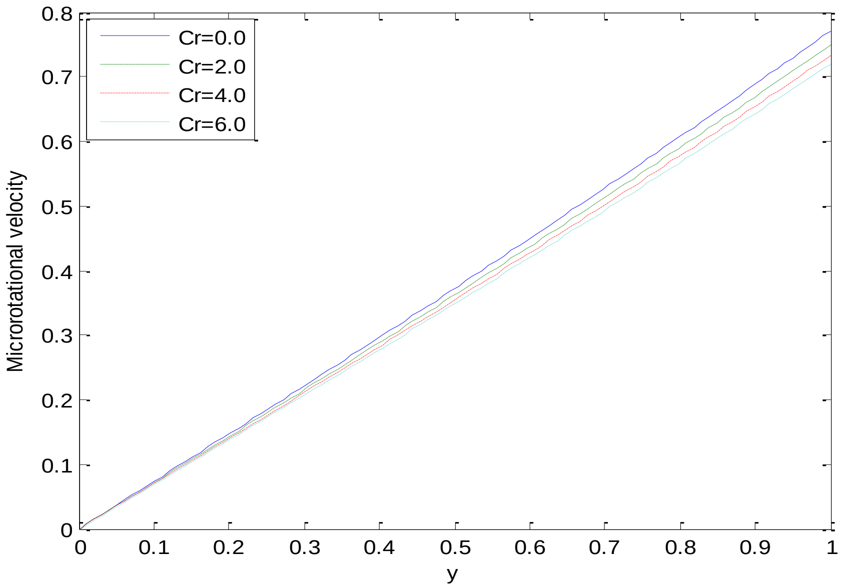

Figure 15: Microrotational velocity profiles for different values of chemical reaction parameter

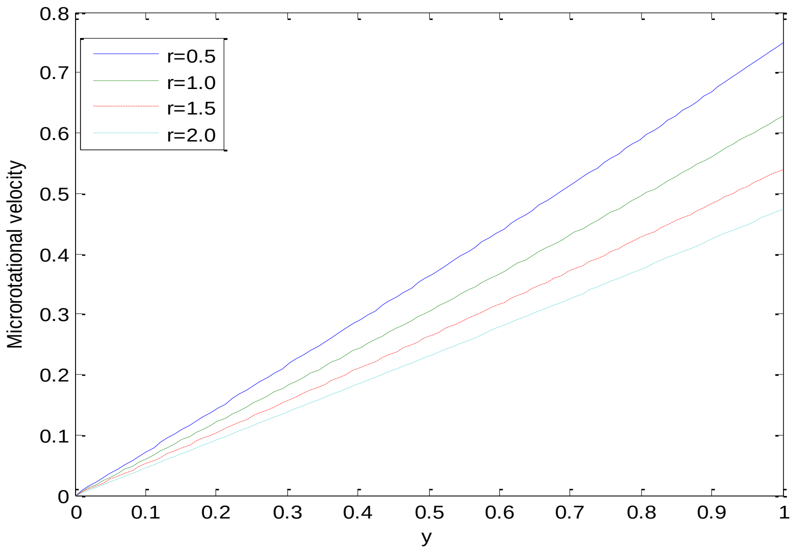

Figure 16: Microrotational velocity profiles for different value of viscosity ratio parameter.

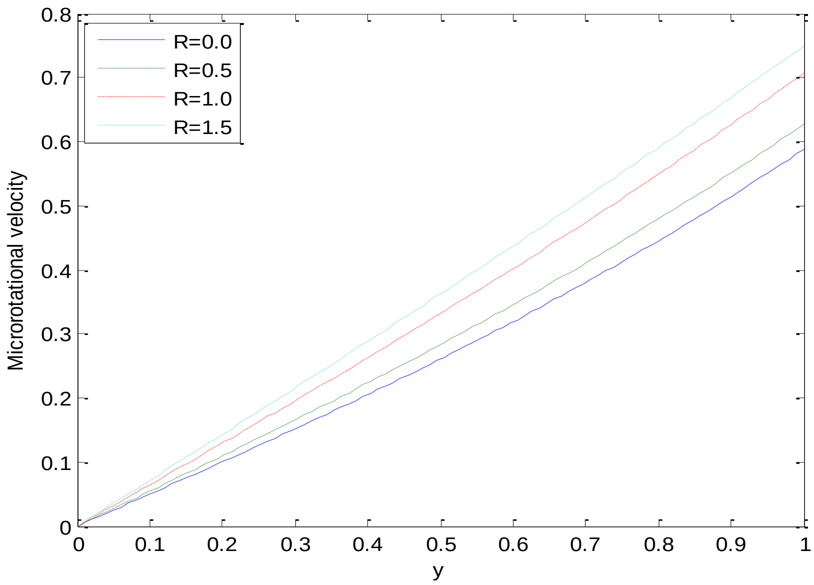

Figure 17: Microrotational velocity for different value of radiation parameter

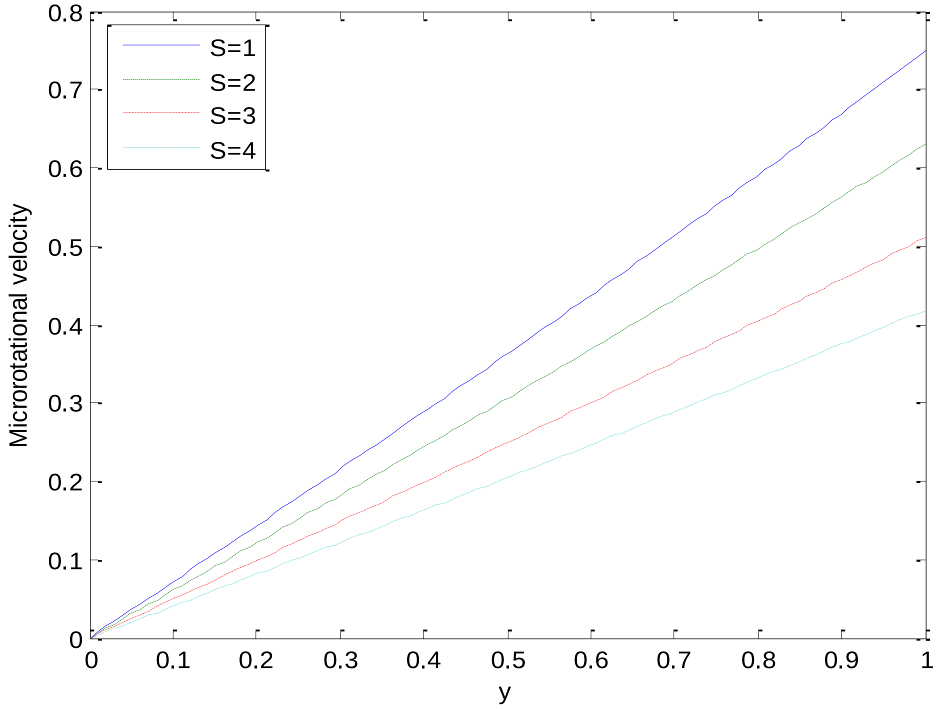

Figure 18: Microrotational velocity profiles for different value of porous medium shape parameter.

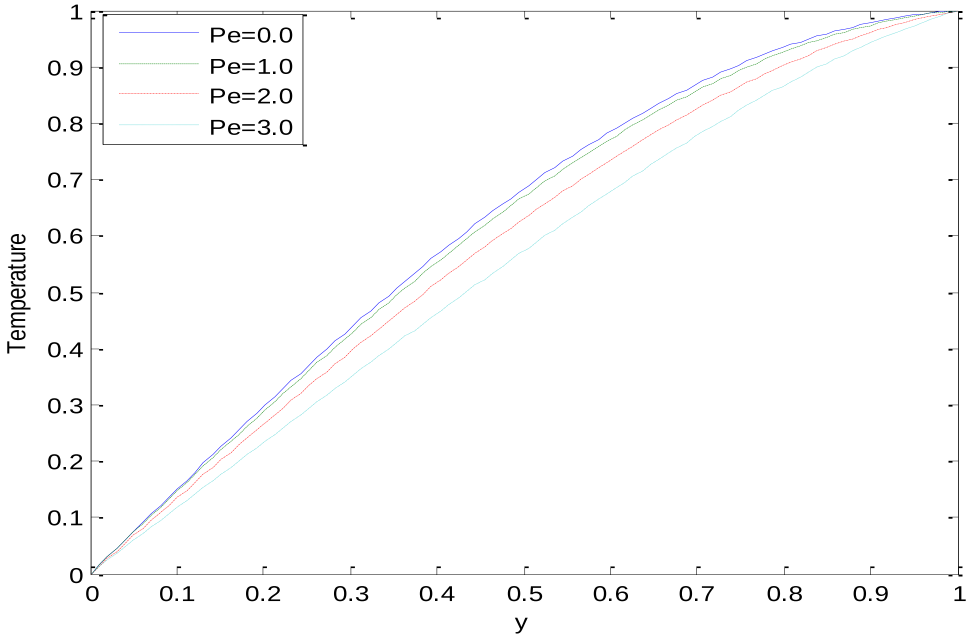

Figure 19: Temperature profiles for different value of peclet number

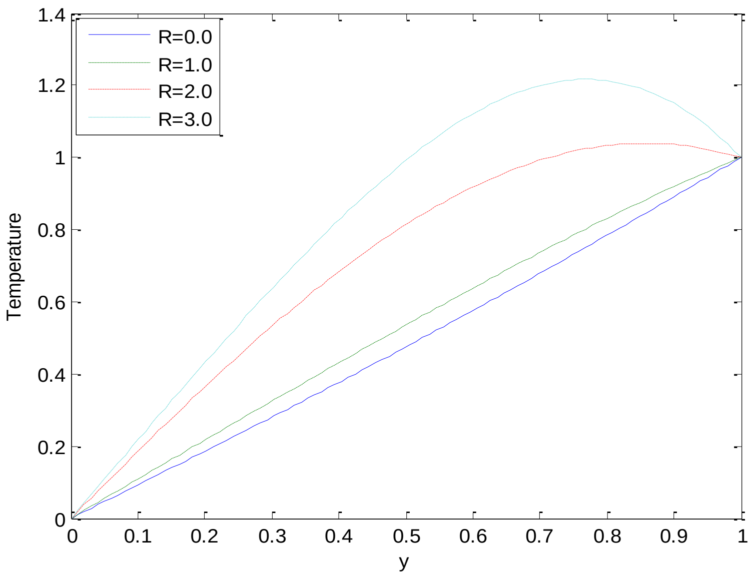

Figure 20: Temperature profiles for different value of radiation parameter

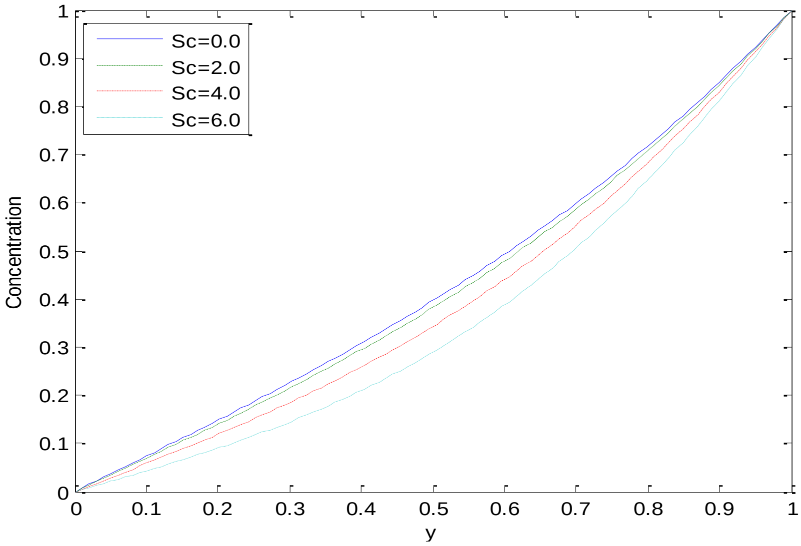

Figure 21: Concentration profiles for different value of Schidmt number

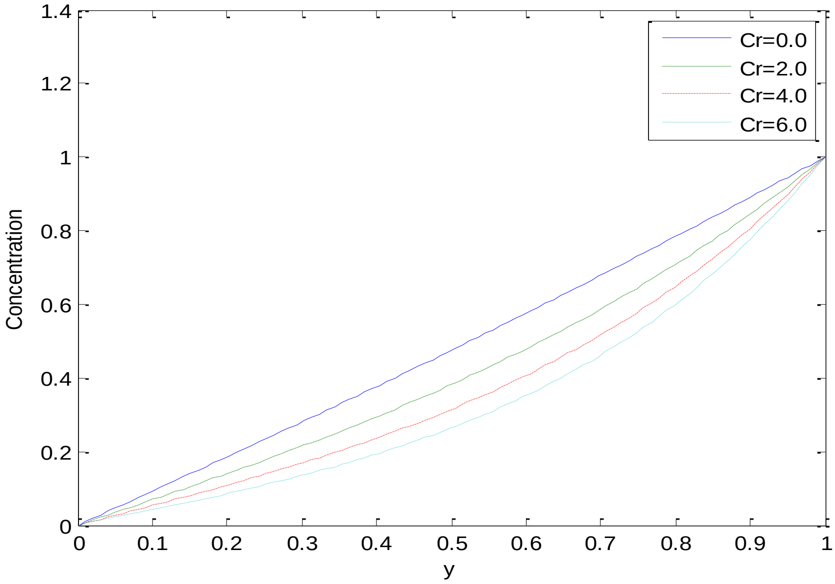

Figure 22: Concentration profiles for different value of chemical reaction parameter

Table: Effects of varied parameters on couple stress coefficient, Nuselt number and Sherwood number.

H	Re	Pe	R	r	Cr	Sc	$W'(1)$	W'(0)
1.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2925	0.2591
2.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2605	0.2331
3.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2236	0.2023
1.0	0.5	2.0	1.5	0.5	2.0	2.0	0.2915	0.2664
1.0	1.0	2.0	1.5	0.5	2.0	2.0	0.2922	0.2642
1.0	1.5	2.0	1.5	0.5	2.0	2.0	0.2925	0.2618
1.0	2.0	0.5	1.5	0.5	2.0	2.0	0.2530	0.2270
1.0	2.0	1.0	1.5	0.5	2.0	2.0	0.2620	0.2327
1.0	2.0	1.5	1.5	0.5	2.0	2.0	0.2754	0.2434
1.0	2.0	2.0	1.0	0.5	2.0	2.0	0.2964	0.2344
1.0	2.0	2.0	2.0	0.5	2.0	2.0	0.2575	0.2471
1.0	2.0	2.0	3.0	0.5	2.0	2.0	0.1434	0.2568
1.0	2.0	2.0	1.5	1.0	2.0	2.0	0.2290	0.1948
1.0	2.0	2.0	1.5	1.5	2.0	2.0	0.1881	0.1607
1.0	2.0	2.0	1.5	2.0	2.0	2.0	0.1591	0.1368
1.0	2.0	2.0	1.5	0.5	1.0	2.0	0.2966	0.2505
1.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2925	0.2471
1.0	2.0	2.0	1.5	0.5	3.0	2.0	0.2888	0.2442
1.0	2.0	2.0	1.5	0.5	2.0	1.0	0.2926	0.2489
1.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2925	0.2471
1.0	2.0	2.0	1.5	0.5	2.0	3.0	0.2918	0.2449
		Pe	R				$-\theta'(1)$	$-\theta'(1)$
1.0	2.0	0.5	1.5	0.5	2.0	2.0	-0.1180	-1.4930
1.0	2.0	1.0	1.5	0.5	2.0	2.0	-0.1522	-1.4612
1.0	2.0	1.5	1.5	0.5	2.0	2.0	-0.2074	-1.4101
1.0	2.0	2.0	1.0	0.5	2.0	2.0	-0.7570	-1.0854
1.0	2.0	2.0	2.0	0.5	2.0	2.0	0.5566	-1.8558
1.0	2.0	2.0	3.0	0.5	2.0	2.0	1.9425	-2.1785
					Cr	Sc	$-\emptyset'(1)$	$-\emptyset'(1)$
1.0	2.0	2.0	1.5	0.5	1.0	2.0	-1.3788	-0.7954
1.0	2.0	2.0	1.5	0.5	2.0	2.0	-1.6438	-0.6886
1.0	2.0	2.0	1.5	0.5	3.0	2.0	-1.8858	-0.5999
1.0	2.0	2.0	1.5	0.5	2.0	1.0	-1.6051	-0.7200
1.0	2.0	2.0	1.5	0.5	2.0	2.0	-1.6438	-0.6886
1.0	2.0	2.0	1.5	0.5	2.0	3.0	-1.7051	-0.6393

Figure 2 – figure 10 which are parabolic in nature with zero at walls and satisfied the boundary conditions, illustrates translational velocity profiles with varied parameters; increase in Hartmann parameter led to decrease in translational velocity which is expected since transverse magnetic field gives rise to a resistive type of force called Lorentz force that has the tendency to slow down fluid motion, translational velocity profile decreases as Reynolds number increases, the effect of increasing Peclet number is to increase the translational velocity profile, increase in parameter that relates microgyration vector to shear stress resulted to increase in translational velocity, translational velocity profile decreases as (Schmidt number/chemical reaction parameter/viscosity ratio parameter) increases, increase in radiation parameter led to increase in translational velocity and the effect of increasing porous medium shape parameter is to decrease the translational velocity which is not surprising because porous medium shape parameter is the square root of Darcy number inverse

Figure 11 – figure 18 which are with zero at walls and satisfied prescribed boundary conditions, depicts microrotational velocity profiles with varied parameters; increase in Hartmann number led to decrease in microrotational velocity, microrotational velocity profile decreases as Reynolds number increases, the effect of increasing peclet number is to increase microrotational velocity of the flow, microrotational velocity increases as parameter that relates microgyration vector to shear stress increases which is not unexpected since $n_1 = 0.5$ is for laminar flow while $n_1 = 1.0$ is for turbulent flow, chemical reaction parameter decreases microrotational velocity of the flow, increase in viscosity ratio led to decrease in microrotational velocity and microrotational velocity of the flow decreases as (radiation parameter/porous medium shape parameter) increases

Figure 19 and figure 20 which are with zero at walls and satisfied boundary conditions, displays the temperature profiles with varied parameters; increase in peclet number decreases the temperature of the flow while the effect of increasing radiation parameter is to increase the temperature of the flow

Figure 20 and figure 21 are with zero at walls and satisfied boundary conditions, shows the concentration profiles with varied parameters; increase in Schmidt number and chemical reaction parameter both decreases the concentration of the flow.

The table demonstrated the effects of varied parameters on couple stress coefficient, Nuselt number and Sherwood number at upper and lower walls respectively; increase in Hartmann number decreases the couple stress coefficient at both upper and lower walls, increase in reynolds number increases the couple stress coefficient at the upper wall but decreases it at lower wall, couple stress coefficient at both lower and upper walls increases as peclet number increases, increase in radiation parameter decreases stress coefficient at the upper wall while it increases it at the lower wall, the effect of increasing viscosity ratio parameter is to decrease couple stress coefficient at both lower and upper wall, the couple stress coefficient at both upper/lower wall decreases as chemical reaction parameter increases, the effect of increasing Schmidt number is to decrease couple stress coefficient at upper/lower wall, increase in peclet number resulted to decrease in Nuselt number at the upper wall while it increases it at the lower wall, the effect of increasing radiation parameter is to increase the Nuselt number at the upper wall but decreases it at the lower wall, increase in chemical reaction parameter led to decrease in Sherwood number at the upper wall while it increases it at the lower wall and the effect of increasing Schmidt number is to decrease the Sherwood number at the upper wall but increases it at the lower wall.

CONCLUSION

Analytical study of MHD oscillatory blood flow in a channel as micropolar fluid in the presence of chemical reaction was conducted. The results are presented and discuss through graphs and a table for pertinent parameters involved. The following conclusion can be drawn from the result obtained.

i. Chemical reaction decreases translational and microrotational velocity of the blood flow
ii. Increase in radiation led to increase in translational velocity.
iii. Increase in viscosity ratio led to decrease in translational and microrotational velocity of the flow
iv. The couple stress coefficient decreases as the rate of chemical reaction increases
v. Increase in chemical reaction decreases the rate of mass transfer at the upper wall.

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