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Slip Effect on MHD Peristaltic flow of Non-Newtonian Fluid through compliant wallsS. TAJODDIN¹ and ARIF KHAN²¹Associate Professor, Dept of Mathematics, Osmania College, Kurnool, Andhra Pradesh, India 518002²Assistant Professor, Dept of Mathematics, Osmania College, Kurnool, , Andhra Pradesh, India 518002Corresponding Author Email: shaikthajoddin1962@gmail.com<http://dx.doi.org/10.22147/jusps-B/290601>**Acceptance Date 15th May, 2017, Online Publication Date 2nd June, 2017****Abstract**

In this paper, we examine the combined effects on peristaltic movement of an electrically conducting Walters-B fluid through a compliant walled channel. Using small wave number move towards, the nonlinear model differential equations are obtained and tackled analytically by regular perturbation method. Expressions for the stream function, velocity, temperature, skin-friction coefficient and heat transfer coefficient are constructed. Pertinent results are presented graphically and discussed quantitatively. It is found that the velocity distribution depresses while the fluid temperature rises with an increase in Hartmann number. The trapping phenomenon is observed and the size of trapped bolus increases with an increase in Hartmann number.

Key words: Thermal radiation; MHD; Peristalsis; Walter-B fluid; compliant walls; Slip conditions; Heat generation

1. Introduction

Peristaltic transport is a form of material transport included by a progressive wave of contraction or expansion along the length of distensible tube mixing and transporting the fluid in the direction of the wave propagation. This kind of phenomenon is termed as peristaltic. It plays an indispensable role in transporting many physiological fluids in the body under various situations as urine transport from kidney to bladder, the movement of chyme in the gastrointestinal tracts, transport of spermatozoa in the

ductus efferent's of the male reproductive tract, movement of ovum in the fallopian tubes, swallowing of food through esophagus and the vasomation of small blood vessels many modern mechanical devices have been designed on the principle of peristaltic pumping to transport the fluids without internal moving parts, for example the blood pump in the heart-lung machine and peristaltic transport of naxious fluid in nuclear industry. The mechanism of peristaltic transport has attracted the attention of many investigators since its investigation by Latham¹³, Burns and pareks², shapero *et al.*²², Fung and Yih³,

Takabatake and Ayukawa²⁵, Akram and Nedeem¹, Mekheimer and Elkot¹⁶, Mekheimer and al -arabi¹⁵, Mekheimer¹⁴, Nadeam and akbar¹⁹, Kothandapani *et al.*¹⁰, of peristaltic flow for different fluids have been reported under various conditions with reference to physiological and mechanical situations. Most of these investigations are confined to the peristaltic flow only in a symmetric channel or tube. Consideration of wall properties in peristalsis is of special value in study of blood flow in arteries and veins, urine flow in the urethras and air flow in the lungs. Peristaltic motion in a compliant wall channel has also been investigated by some researchers. Radhakrishnamacharya and Srinivasulu²⁰ analyzed the influence of wall properties on peristaltic motion of Newtonian fluid with heat transfer. Peristaltic motion of micro polar fluid in circular cylindrical tubes with wall properties is discussed by Muth *et al.*¹⁷, Hayat *et al.*^{5,6} examined the MHD peristaltic flow of Jeffery and Johnson – Segalman fluids with compliant walls. Srinivas and Kothandapani²³ analyzed the heat and mass transfer effects on MHD peristaltic flow of Newtonian fluid in a porous channel with compliant walls. Riaz *et al.*²¹ investigated the peristaltic motion of Prandtl fluid in rectangular duct with wall properties. Recently, peristaltic flow of Burgers fluid in compliant walls channel was investigated by Javed *et al.*⁹. Peristaltic flow with compliant walls and Hall current was studied by Gad⁴. Very recently, the combined influence of heat and mass transfer on the peristaltic motion of pseudoplastic fluid with wall properties was analytically explored by Hina *et al.*⁷. Slip effects on the peristaltic flow of Eyring-Powell fluid with wall properties were examined by Hina⁸. Amongst the many suggested models, Walters²⁶ has developed a physically accurate mathematical model for the rheological equation of state of a viscoelastic fluid with short memory. This model has been shown to capture the characteristic of actual viscoelastic polymer solutions, hydrocarbons, paints and other chemical engineering fluids. The Walters-B fluid model generates highly non-linear flow equations which have order higher than that of the Navier-Stokes equations.

It also incorporates elastic properties of the fluid which are important in extensional behavior of polymers. Peristalsis of Walters-B fluid with wall properties has never been addressed previously. Thus Margiam Javed *et al.*¹⁸ is undertaking to fill this void by incorporating velocity slip and temperature jump conditions.

Recently, Krishna and Swarnalathamma²⁷ discussed the peristaltic MHD flow of an incompressible and electrically conducting Williamson fluid in a symmetric planar channel with heat and mass transfer under the effect of inclined magnetic field. Swarnalathamma and Krishna²⁸ discussed the theoretical and computational study of peristaltic hemodynamic flow of couple stress fluids through a porous medium under the influence of magnetic field with wall slip condition. Krishna and M.G. Reddy²⁹ discussed MHD free convective rotating flow of visco-elastic fluid past an infinite vertical oscillating plate. Krishna and G.S. Reddy³⁰ discussed unsteady MHD convective flow of second grade fluid through a porous medium in a rotating parallel plate channel with temperature dependent source.

In view of the above facts, in this paper, we examine the combined effects of magnetic field, thermal radiation, heat source, velocity slip and thermal jump on peristaltic transport of an electrically conducting Walters-B fluid through a compliant walled channel.

2. Formulation and Solution of the Problem:

Let us consider the unsteady peristaltic transport of an incompressible viscous electrically conducting and radiating Walters-B fluid in a channel of width $2d$ (see Fig. 1). The channel walls are of compliant nature. The temperatures of the lower and upper walls of the channel are maintained at T_o and T_1 respectively. The geometry of the wall is

$$y = \pm \eta = \pm \left[d + a \sin \left(\frac{2\pi}{\lambda} (x - ct) \right) \right], \quad (1)$$

where λ is the wavelength, c is the wave speed, a is the wave amplitude and x and y are the Cartesian

coordinates with x measured in the direction of the wave propagation and y measured in the direction normal to the mean position of the channel walls.

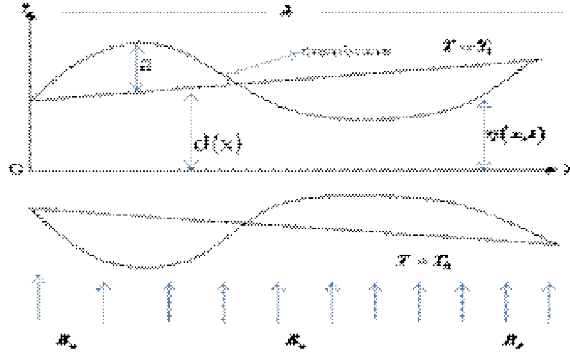


Fig.1. Geometry of the problem.

The flow problem for Walters-B fluid model is described as

The continuity equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \quad (2)$$

The x component of momentum equation:

$$\rho \left(\frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} \right) u = -\frac{\partial p}{\partial x} + \frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{xy}}{\partial y} - \sigma B_o^2 u, \quad (3)$$

The y component of momentum equation:

$$\rho \left(\frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} \right) v = -\frac{\partial p}{\partial y} + \frac{\partial S_{yx}}{\partial x} + \frac{\partial S_{yy}}{\partial y}, \quad (4)$$

where

$$S_{xx} = 4\eta_o \frac{\partial u}{\partial x} - 2\kappa_o \left[2 \frac{\partial^2 u}{\partial x \partial t} + 2 \left(u \frac{\partial^2 u}{\partial x^2} + v \frac{\partial^2 u}{\partial x \partial y} \right) - 4 \left(\frac{\partial u}{\partial x} \right)^2 \right], \quad (5)$$

$$S_{yy} = 2\eta_o \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) - 2\kappa_o \left[2 \frac{\partial^2 u}{\partial y \partial t} + \frac{\partial^2 v}{\partial x \partial t} - 2 \frac{\partial u}{\partial x} \frac{\partial u}{\partial y} + \left(u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} \right) \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) \right. \\ \left. - \frac{\partial v}{\partial y} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) - \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) - 2 \frac{\partial v}{\partial x} \frac{\partial v}{\partial y} \right], \quad (6)$$

$$S_{yy} = 4\eta_o \frac{\partial v}{\partial y} - 2\kappa_o \left[2 \frac{\partial^2 v}{\partial y \partial t} + 2 \left(u \frac{\partial^2 v}{\partial x \partial y} + v \frac{\partial^2 v}{\partial y^2} \right) - 4 \left(\frac{\partial v}{\partial y} \right)^2 \right], \quad (7)$$

The energy balance equation is

$$\rho C_p \left(\frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} \right) T = \xi \nabla^2 T + \Phi - \frac{\partial q_r}{\partial y} + Q_o, \quad (8)$$

where

$$\Phi = S_{xx} \frac{\partial u}{\partial x} + S_{xy} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) + S_{yy} \frac{\partial v}{\partial y}, \quad (9)$$

The equation governing the motion of flexible wall is expressed as

$$L(\eta) = p - p_o, \quad (10)$$

where p_o is pressure on the outside surface of the wall and L is an operator which represents the motion of stretched membrane with viscous damping forces such that

$$L = -\tau \frac{\partial^2}{\partial x^2} + m \frac{\partial^2}{\partial t^2} + d_1 \frac{\partial}{\partial t}, \quad (11)$$

in which τ is the elastic tension in the membrane, m is the mass per unit area and d_1 is the coefficient of damping. For simplicity we assume that p_o is zero.

The continuity of stress at $y = \pm \eta(x, t)$ demands that the pressure exerted by the walls on the fluid is equal and opposite to the pressure exerted by the fluid on the walls. Further the deformation condition suggests that the transverse displacements of the walls are equal to the corresponding y - displacements of the fluid at the instantaneous positions of the interfaces. Combining the continuity of stress and condition of deformation the no-separation condition at the boundaries are

$$\frac{\partial}{\partial x} L(\eta) = \frac{\partial p}{\partial x} = \frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{xy}}{\partial x} - \rho \left(\frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} \right) u,$$

$$\text{at } y = \pm \eta(x, t). \quad (12)$$

Such type of boundary condition is not restricted to the present problem. In fact it is also employed in other applications such as finishing of painted walls, frictional drag reduction on the hulls of ships and submarines etc. The radiative heat flux in the x – direction is considered as negligible compared to y – direction. By using Rosseland approximation for thermal radiation, the radiative heat flux q_r is specified by

$$q_r = -\frac{16\sigma^* T_0^3}{3k^*} \frac{\partial T}{\partial y}, \quad (13)$$

where σ^* and k^* are the Stefan – Boltzmann constant and mean absorption coefficient respectively. The velocity and thermal slip conditions are

$$u \pm \beta_1 S_{xy} = 0 \quad \text{at}$$

$$y = \pm \eta(x, t) = \pm \left[d + a \sin \left(\frac{2\pi}{\lambda} (x - ct) \right) \right], \quad (14)$$

$$T \pm \beta_2 \frac{\partial T}{\partial y} = \left\{ \begin{matrix} T_1 \\ T_o \end{matrix} \right\} \quad \text{at } y = \pm \eta \quad (15)$$

Here u and v are the velocity components in the x and y directions respectively and $\rho, t, p, \eta_o, K_o, \xi, T, Q_o$ and k^* are the fluid density, the time, the pressure, the limiting viscosity at small shear rates, the short memory coefficient, the specific heat, the thermal conductivity, the temperature, the dimensional heat absorption coefficient and the thermal conductivity respectively, β_1 is the velocity slip parameter and β_2 is the thermal slip parameter. Let

$$u = \frac{\partial \psi}{\partial y}, \quad v = -\frac{\partial \psi}{\partial x}. \quad (16)$$

We introduce the following dimensionless parameters and variables;

$$x^* = \frac{x}{\lambda}, \quad y^* = \frac{y}{d}, \quad \psi^* = \frac{\psi}{cd}, \quad t^* = \frac{ct}{\lambda}, \quad \eta^* = \frac{\eta}{d}, \quad \delta = \frac{d}{\lambda},$$

$$\varepsilon = \frac{a}{d}, \quad p^* = \frac{d^2 p}{\eta_o c \lambda}, \quad \text{Re} = \frac{cd}{\nu}, \quad \kappa = \frac{K_o c}{\eta_o d},$$

$$E_1 = -\frac{\tau d^3}{\lambda^3 \eta_o c}, \quad E_2 = \frac{mcd^3}{\lambda^3 \eta_o}, \quad E_3 = \frac{cd^3}{\lambda^2 \eta_o}, \quad \beta_1^* = \frac{\beta_1}{d}, \quad \beta_2^* = \frac{\beta_2}{d}$$

$$\Phi^* = \frac{d^2}{\eta_o c^2} \Phi, \quad \text{Pr} = \frac{\eta_o C_p}{\xi}, \quad E = \frac{c^2}{C_p (T_1 - T_o)},$$

$$\theta = \frac{T - T_o}{T_1 - T_o}, \quad M = \sqrt{\frac{\sigma}{\eta_o}} B_o d, \quad \beta = \frac{Q_o d^2}{\xi (T_1 - T_o)}, \quad Rd = \frac{16\sigma^* T_o^3}{3k^* \xi} \quad (17)$$

and dropping the asterisk for brevity, Eq. (2) is automatically satisfied and Eqs. (3) - (9) together with boundary conditions (14) and (15) with the help of (10) - (13), (16) and (17) take the form below:

$$\text{Re} \delta \left(\psi_{xt} + \psi_y \psi_{xy} - \psi_x \psi_{yy} \right) = -\frac{\partial p}{\partial x} - M^2 \frac{\partial \psi}{\partial y} + \delta S_{xx,x} + S_{xy,y} \quad (18)$$

$$\text{Re} \delta^3 \left(\psi_{xt} - \psi_y \psi_{xx} + \psi_x \psi_{xy} \right) = -\frac{\partial p}{\partial y} + \delta^2 S_{xy,x} + \delta S_{yy,y} \quad (19)$$

where

$$S_{xx} = 4\delta \psi_{xy} - 2\kappa \delta^2 \left[\begin{matrix} 2\psi_{xyt} + 2(\psi_y \psi_{xxy} - \psi_x \psi_{xyy}) \\ -4\psi_{xy}^2 + 2\psi_{xx}(\psi_{yy} - \delta^2 \psi_{xx}) \end{matrix} \right] \quad (20)$$

$$S_{xy} = 2(\psi_{yy} - \delta^2 \psi_{xx}) - 2\kappa \left[\begin{matrix} \delta \psi_{yxt} - \delta^3 \psi_{xxt} + \delta \psi_y \psi_{xyy} - \delta^3 \psi_y \psi_{xxx} \\ -\delta \psi_x \psi_{yyy} + \delta^3 \psi_x \psi_{xyy} \\ -2\delta \psi_{xy} \psi_{yy} - 2\delta^3 \psi_{xx} \psi_{xy} \end{matrix} \right] \quad (21)$$

$$S_{yy} = -4\delta \psi_{xy} - 2\kappa \left[\delta^2 \left(\begin{matrix} -2\psi_{xyt} - 2\psi_y \psi_{xxy} + 2\psi_x \psi_{xyy} \\ + 2\psi_{xx} \psi_{yy} - 4\psi_{yy}^2 \end{matrix} \right) - 2\psi_{yy}^2 \right], \quad (22)$$

$$\text{Pr Re} \delta \left(\frac{\partial \theta}{\partial t} + \psi_y \frac{\partial \theta}{\partial x} - \psi_x \frac{\partial \theta}{\partial y} \right) = \left(\frac{\partial^2 \theta}{\partial y^2} + \delta^2 \frac{\partial^2 \theta}{\partial x^2} \right) + Br \Phi + \beta + Rd \frac{\partial^2 \theta}{\partial y^2}, \quad (23)$$

$$\Phi = \delta S_{xx} \psi_{xy} + S_{xy} \left(\psi_{yy} - \delta^2 \psi_{xx} \right) - \delta \psi_{xy} S_{yy}, \quad (24)$$

The associated boundary conditions are:

$$\psi_y \pm \beta_1 S_{xy} = 0, \text{ at } y = \pm \eta = \pm [1 + \varepsilon \sin 2\pi(x-t)], \quad (25)$$

$$\begin{aligned} \frac{\partial p}{\partial x} &= (\delta S_{xx,x} + S_{xy,y}) - \text{Re} \delta [\psi_{yt} + \psi_y \psi_{xy} - \psi_x \psi_{yy}] - M^2 \frac{\partial \psi}{\partial y} \\ &= \left[E_1 \frac{\partial^3}{\partial x^3} + E_2 \frac{\partial^3}{\partial x \partial t^2} + E_3 \frac{\partial^2}{\partial x \partial t} \right] \eta \end{aligned}$$

$$\text{at } y = \pm \eta \quad (26)$$

$$\theta \pm \beta_2 \theta_y = \begin{cases} 1 \\ 0 \end{cases} \text{ at } y = \pm \eta \quad (27)$$

where ψ is a stream function, M is the Hartmann number, Pr is the Prandtl number, $Br (= \text{Pr} E)$ is the Brinkman number, E is the Eckert number, δ is the wave number, Re is the Reynolds number, Rd is the Radiation parameter, β is the heat generation

parameter, E_1 , E_2 and E_3 are the non-dimensional compliant wall parameters.

In order to obtain the analytical solution of above mentioned problem, an effort has been made by employing power series expansion in the small parameter δ . This solution should be valid for any arbitrary set of values of all parameters used in mathematical model. Major equations governing the perturbation solution method are as follows:

$$\psi = \psi_0 + \delta \psi_1 + \dots, \quad (28)$$

$$\theta = \theta_0 + \delta \theta_1 + \dots, \quad (29)$$

$$S_{xx} = S_{xx0} + \delta S_{xx1} + \dots, \quad (30)$$

$$S_{xy} = S_{xy0} + \delta S_{xy1} + \dots, \quad (31)$$

$$S_{yy} = S_{yy0} + \delta S_{yy1} + \dots, \quad (32)$$

$$Z = Z_0 + \delta Z_1 + \dots, \quad (33)$$

The stream function is given by

$$\psi = C_2 y + C_4 \sinh(Ny) + \delta \left(\begin{aligned} &C_6 y + C_8 \sinh(Ny) + B_{21} y \cosh(Ny) \\ &+ B_{22} y^2 \sinh(Ny) + B_{23} \sinh(Ny) \\ &+ B_{24} \sinh(2Ny) \end{aligned} \right) \quad (34)$$

The velocity obtained from (16), which is given by

$$u = C_2 + C_4 N \cosh(Ny) + \delta \left(\begin{aligned} &C_6 + C_8 N \cosh(Ny) \\ &+ B_{21} (Ny \sinh(Ny) + \cosh(Ny)) \\ &+ B_{22} (Ny^2 \cosh(Ny) + 2y \sinh(Ny)) \\ &+ B_{23} N \cosh(Ny) + 2B_{24} N \cosh(2Ny) \end{aligned} \right) \quad (35)$$

The temperature is given by

$$\begin{aligned} \theta &= D_1 + D_2 y + B_{43} \cosh(2Ny) + B_{44} y^2 + \\ &\delta \left(\begin{aligned} &D_3 + D_4 y + B_{138} y^2 + B_{139} y^3 + B_{140} y^4 + B_{141} \cosh(Ny) + B_{142} \sinh(Ny) \\ &+ B_{143} y \cosh(Ny) + B_{144} y \sinh(Ny) + B_{145} y \sinh(2Ny) + B_{146} \cosh(2Ny) \\ &+ B_{147} \cosh(3Ny) + B_{148} \cosh(4Ny) + B_{149} y \sinh(3Ny) + B_{150} y^2 \cosh(2Ny) \\ &+ B_{151} y \cosh(3Ny) + B_{152} \sinh(3Ny) + B_{153} y^2 \cosh(3Ny) + B_{154} y^2 \cosh(Ny) \\ &+ B_{155} y \cosh(2Ny) + B_{156} \sinh(2Ny) + B_{157} y^3 \sinh(2Ny) \\ &+ B_{158} y^4 \cosh(2Ny) + B_{159} y^6 \end{aligned} \right) \end{aligned} \quad (36)$$

The shear stress and rate of heat transfer (Nusselt number) at the wall are defined in terms of skin friction coefficient (C_f) and Nusselt number (Nu) as follows:

$$C_f = \eta_x (\psi_{0,yy} + \delta \psi_{1,yy}), \quad (37)$$

$$Z = \eta_x (\theta_{0,y} + \delta \theta_{1,y}), \quad (38)$$

where the constants are involved in Eqs. (34) – (36) can obtained through simple algebraic computations.

4. Results and Discussion

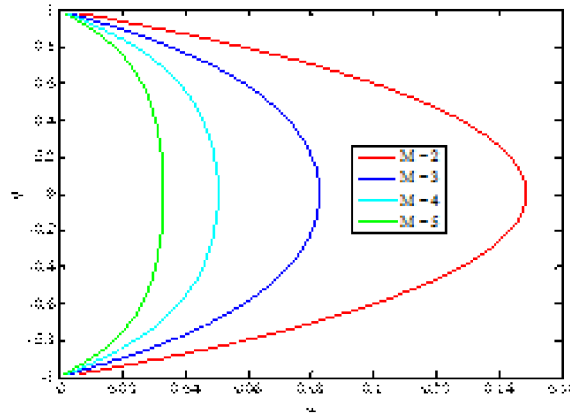
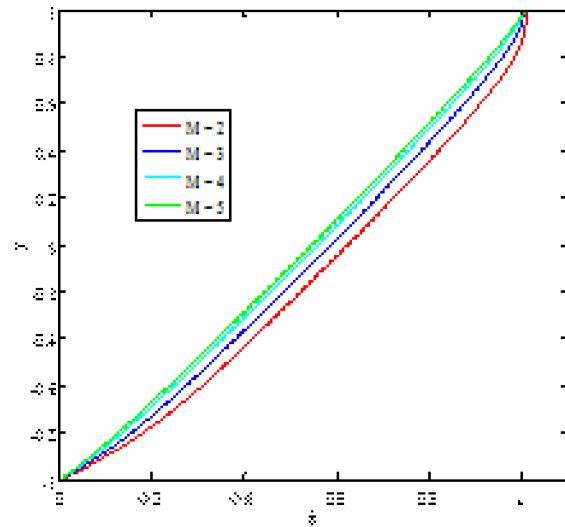
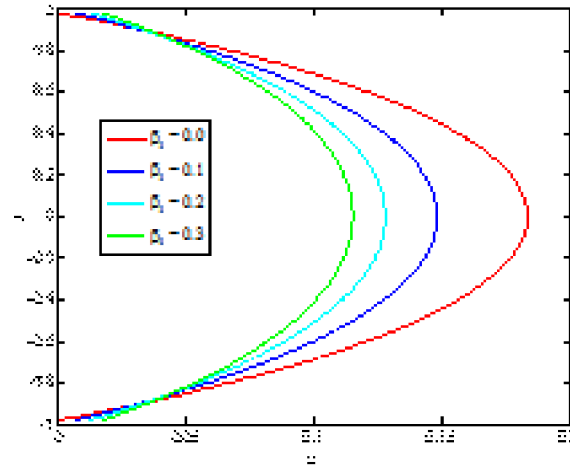
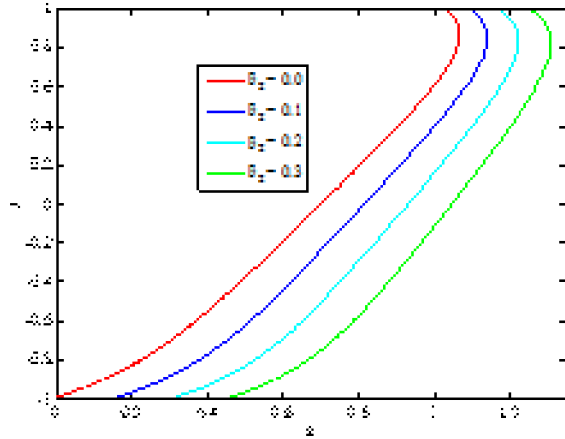
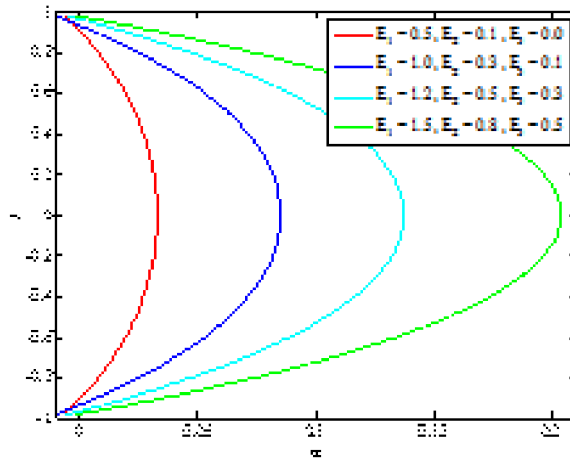
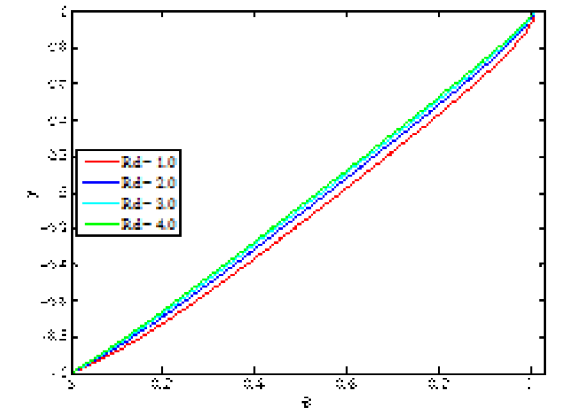
To the best of the author's knowledge no attempt has been done for thermal radiation and magnetohydrodynamic effects on the peristaltic flow of Walters-B fluid in a compliant wall. The purpose of the present investigation is to analyze the heat transfer and MHD effects on the peristaltic flow of Walters-B fluid in a compliant wall channel with thermal radiation and heat generation. The simplified equations are then solved using a regular perturbation method. Graphical results are presented for velocity, temperature, skin friction coefficient and heat transfer coefficient. In this section, the numerical results of the analytical expressions obtained for the fluid velocity, temperature, skin friction and Nusselt number are displayed graphically in Figs. 2 - 16 and discussed quantitatively. The following parameter values are utilized for numerical computations: $E_1=1$, $E_2=0.4$, $E_3=0.5$, $Re=1$, $x=0.5$, $t=0.8$, $M=3$, $Br=0.8$, $Rd=1$, $Pr=0.7$, $\beta_1=0.1$, $\beta_2=0.01$, $\beta=0.1$, $\varepsilon=0.01$, $\kappa=2$, $\delta=0.01$.

Figs. 2 – 4 show the behavior of parameters involved in the velocity u . Fig. 2. depicts that the velocity reduces as M increases because of the Lorentz force associated with the applied magnetic field along the transverse direction which opposes the flow. Fig.3. reveals that the velocity depresses with increase of β_1 due to wall slip. Fig.4. shows the behavior of compliant wall parameters E_1 , E_2 and E_3 on the fluid velocity. It is found that the velocity diminishes with an increase in wall damping coefficient E_3 . This parameter has oscillatory resistance to the flow that's why velocity decreases with wall damping coefficient E_3 . The

velocity is increasing function of E_1 and E_2 physically means that the wall elastance assists the flow. Also the velocity profile is parabolic for fixed values of the parameter and its magnitude is maximum near the center of the channel.

The effect of various physical parameters on the temperature is shown in Figs. 5 – 8. The nature of temperature is parabolic through all figures. In Figs. 5 and 6 we observed that the fluid temperature rises with an increase in Hartmann number M and the thermal slip parameter β_2 . It may also be noted from Fig. 6 that for any values of γ , temperature increases with the height of the channel after attaining its maximum, it decreases. An increase in thermal radiation Rd absorption decreases the fluid temperature as shown in Fig.7. Fig. 8. emphasizes that as heat generates during blood flow in arterioles, there is a significant increase in thickness of boundary layer as heat generation parameter β enhances. Thereby the temperature of the boundary layer increased by appreciable extend. The effect of various physical parameters on the skin-friction coefficient is shown in Table 1. Stress increases with increasing Br , M and Rd and reduces with increasing Pr , β_2 and δ . Like wise, the effects of thermophysical parameters on heat transfer coefficient. Heat transfer coefficient has oscillatory behavior which is expected in view of peristalsis and compliant wall effects. Fig.11 shows that the heat transfer coefficient enhances when M increases. We also noticed that the heat transfer coefficient depresses when an increase in Rd and β . Nu enhances with Br and δ reduces with Pr . Trapping is an important phenomenon in peristaltic motion. Generally the shape of streamlines shows the effect of boundary wall on the flow pattern. Interestingly, the streamlines split to form re-circulating closed streamlines called bolus within the channel. Figs. 9 and 10 revealed that that the size of trapped bolus increases with a rise in the intensity of magnetic field M .

Comparison of a special case of our present study (i.e. $Rd=0$, $M=0$, $\beta=0$) with that of recent results presented by Javed *et al.* (2016) is presented in Fig.16 and an excellent agreement is observed.

Fig. 2. The velocity profile for u against M .Fig. 5. The temperature profile against M .Fig.3. The velocity profile for u against β_1 Fig.6. The temperature profile against β_2 Fig. 4. The velocity profile for u against E_1 , E_2 and E_3 Fig. 7. The temperature profile against Rd

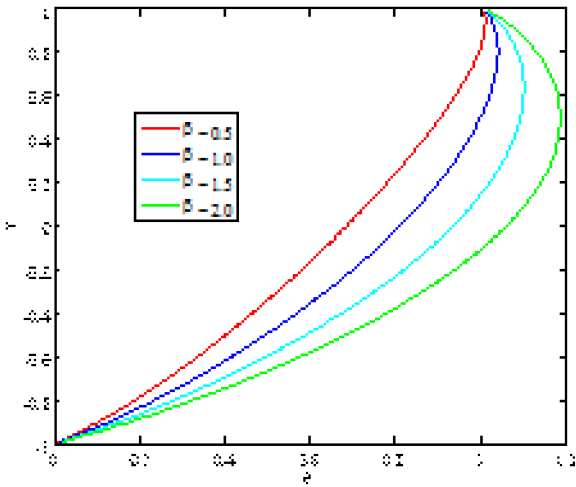


Fig. 8. The temperature profile against β

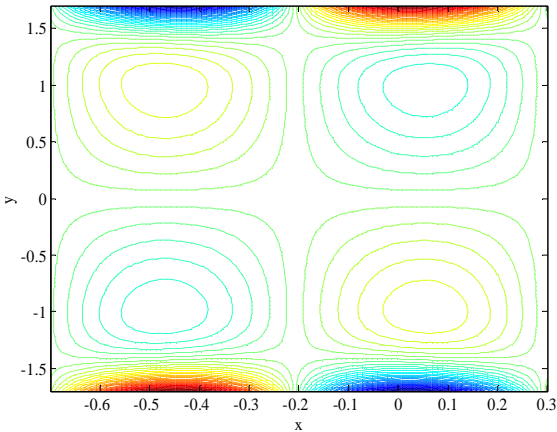


Fig. 10. The Stream lines for $M = 4$.

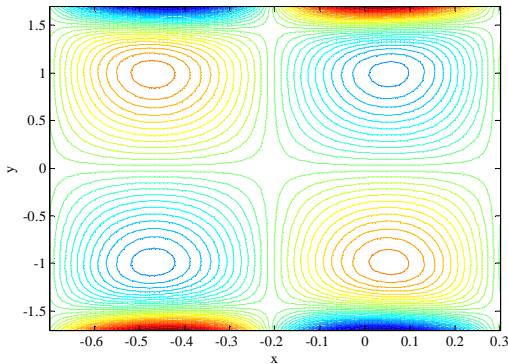


Fig. 9. The Stream lines for $M = 3$.

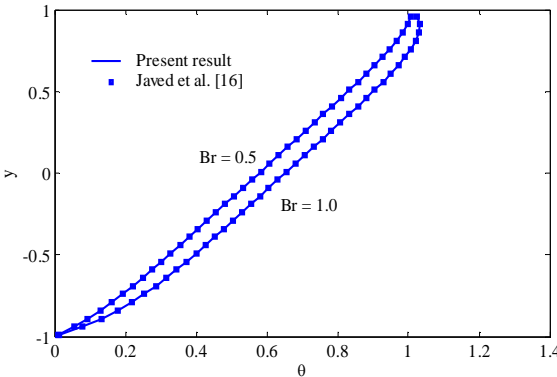


Fig. 11. Comparison results with Javed *et al.* (2016)

Br	M	Pr	δ	Rd	β_2	τ	Nu
0.8	0.5	0.71	0.01	1	0.1	0.852214	0.588795
1						0.955855	0.658854
1.5						1.528956	0.788549
	1					1.522487	0.855280
	2					2.145521	0.945286
		3				0.522489	0.225262
		7				0.200145	0.141122
			0.02			0.142552	0.988569
			0.03			0.002551	1.478742
				2		2.558547	0.255478
				3		3.225546	0.046558
					0.2	0.585547	0.255479
					0.3	0.336325	0.050254

4. Conclusions

This study examines the influence of thermal radiation absorption on the peristaltic flow of hydromagnetic Walter-B fluid flow with heat transfer through a compliant walled channel. The analytical solution has been evaluated using regular perturbation method. The expressions for velocity, temperature, skin-friction coefficient, heat transfer coefficient and stream function have been discussed graphically. The following observations have been found:

1. The velocity field diminishes with an increase in M and β_1 .
2. The fluid temperature rises with an increase M and β but decreases with Rd .
3. The absolute value of skin friction coefficient increases with an increase in M .
4. The heat transfer coefficient increases with an increase M and Rd , while the opposite trend is observed with an increase in β .
5. Size of trapped bolus increases with an increase in Hartmann number M .

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