

Effective effects of temperature distribution and pressure gradient parameter in the curved peristaltic channel of non-Newtonian Walter's-B fluid

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Abstract

The current work is concerned with studying the effective effects of temperature distribution and pressure gradient in the curved channel for non-Newtonian Walter's - B fluid. A fluid moving through an asymmetric curved peristaltic channel out of the porous medium

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with variable viscosity and non-slippery conditions on a temperature distribution, pressure gradient, pressure rise, and concentration. The heat equation was formulated by including the term heat source. The equations governing momentum, energy, and concentration were simplified under long-wavelength constraints and small Reynolds number estimates. A mathematical expression for the nonlinear partial equations was determined analytically in terms of the axial and transverse coordinates and by the regular turbulence for small values of the viscosity parameter of the Reynolds model. The approximation was used to derive series solutions for the temperature distribution field, the pressure gradient field and the evolution of the pressure rise. Adding to the focus area and performing numerical calculations of the pressure rise field for each wavelength. Explaining the effect of the physical parameters in this model on the computational results and the mathematical program "MATHEMATICA".

Subject Classification: Primary 93A30, Secondary 49K15.

Keywords: Curved peristaltic channel, Soret number, Pressure rise, Boundary conditions, Perturbation method, Walter's-B fluid.

1. Introduction

Some researchers have focused closely on the peristaltic flow of non-Newtonian fluids ([1],[2]). In addition to waste and sewage, there are health and nuclear reactors [3]. The study has many environmental, industrial, and medical applications, such as the spread of pollution in straits and difficult marine terrain, in addition to glandular channels and arteries; however, research that offers this advantage is rare due to taking into account the curved coordinates in the equations of motion, which makes the non-linear differential equations very complex. There are research studies conducted in curved channels, as mentioned in the sources [4]. Clear progress has been made in peristaltic transport using curved coordinates, Alshareef [5]. A series of research has begun to address the effect of the curvature parameter on fluid flow in symmetrical and asymmetrical channels, as in the references [6]. Also, see ([7],[8]). In this research Paper, a non-Newtonian Walter 's-B fluid was studied as a model of a viscous fluid that has distinct properties of viscosity and elasticity. Many researchers have studied it across different configurations and dimensions of this fluid, as well as its relaxation and retardation times, and it exhibits the behavior of linear viscous fluids due to its various industrial applications. Some studies in this field ([9],[10],[11]) are discussed. In all previous studies, the viscosity was assumed constant, but in this paper, the variation of viscosity with temperature will be considered. We will study thermophoresis, such as dissipation and electrophoresis, in the two equations of motion, describing them in terms of the Reynolds number. The energy equation, describing them with the Brinkman number, is among the conditions for non-slip speed as well. All the aforementioned equations were simplified using long-wavelength and low-Reynolds-number approximations. All non-Linear differential equations were solved analytically using the regular perturbation technique for small values of the viscosity parameter of the Reynolds temperature model. Solutions of the

temperature distribution, pressure gradient function, and the pressure rise function were given while studying the effect of all physical Factors. Information contained in the above distributions is explained graphically through drawings in the mathematical program "MATHEMATICA" software.

2. Materials and Methods

Our hypothesis is based on the two-dimensional motion for the viscous and incompressible non-Newtonian Walter's - B fluid in a curved peristaltic channel with the width ($2a$), & center (0) of half a diameter (R), and considered to be infinite. This can be seen in Figure 1. The Peristaltic flows for this channel were created due to transverse declinations for the sine waves for little amplitude (b), which is set for the curved elastic walls of a duct. An inertia effect is assumed to be relatively small. A duct wall maintainer at (T_0) temperature and two wall equations are described as follows, see Fig 1 in [7]:

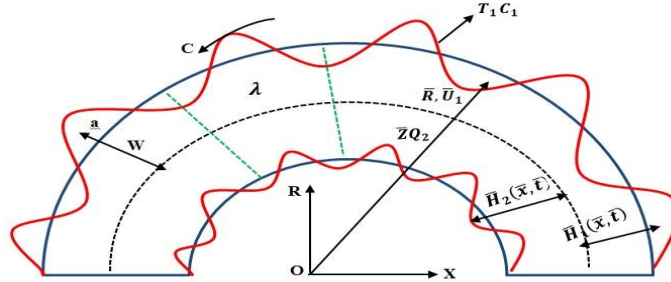


Figure 1
Physical Sketch of Fluid Flow in a Curved Channel.

$$\left. \begin{aligned} \bar{H}_1(\bar{x}, \bar{t}) &= a + b \sin\left(\frac{2\pi}{\lambda}(\bar{x} - c\bar{t})\right) \\ \bar{H}_2(\bar{x}, \bar{t}) &= -a - b \sin\left(\frac{2\pi}{\lambda}(\bar{x} - c\bar{t} + \phi)\right) \end{aligned} \right\} \quad \dots(1)$$

When ($\bar{X}$) be axial distances, (R) is the radial distances, be radius, (b) is implitude wave, λ is the wavelength while (λ) is large compared with (a) such that $\frac{a}{\lambda} \ll 1$. A velocity component in $\bar{R}$ & $\bar{X}$ directions is $\bar{V}$ & $\bar{U}$ respectively. A flow for walter's -B fluid in the peristaltic curved channel is consequent to contractions & dilation for flexible walls for channel, knowing that flow is laminar that mean velocity field is as follows:

$$\bar{V} = (\bar{V}(\bar{R}, \bar{X}, \bar{t}), \bar{U}(\bar{R}, \bar{X}, \bar{t}), 0) \quad \dots(2)$$

governing equation for Walter's - B fluid with variable viscosity with respect to temperature can be described as [8]:

$$\tau = 2\eta_0 w - 2k_0 w^* , \quad \dots(3)$$

where

$$w^* = \frac{\partial w}{\partial t} + (v \cdot \nabla)w - w \cdot \nabla v - (\nabla v)^T w \quad \dots (4)$$

$$\& \quad \frac{R^0}{r+R^0} \frac{\partial \bar{u}}{\partial \bar{x}} + \frac{\partial \bar{v}}{\partial \bar{r}} + \frac{\bar{v}}{\bar{r}+R^0} = 0 \quad \dots(5)$$

$$\rho \left(\frac{\partial \bar{v}}{\partial \bar{t}} + \bar{v} \frac{\partial \bar{v}}{\partial \bar{r}} + \frac{UR^0}{\bar{r}+R^0} \frac{\partial \bar{v}}{\partial \bar{x}} - \frac{\bar{u}^2}{\bar{r}+R^0} \right) = -\frac{\partial \bar{P}}{\partial \bar{r}} + \frac{1}{\bar{r}+R^0} \frac{\partial}{\partial \bar{r}} [(\bar{r}+R^0) \bar{\tau}_{\bar{r}\bar{r}}] +$$

$$\left(\frac{R^0}{\bar{r}+R^0} \right) \frac{\partial \bar{\tau}_{\bar{r}\bar{x}}}{\partial \bar{x}} - \frac{1}{\bar{r}+R^0} \bar{\tau}_{\bar{x}\bar{x}}, \quad \dots(6)$$

$$\rho \left(\frac{\partial \bar{u}}{\partial \bar{t}} + \bar{v} \frac{\partial \bar{u}}{\partial \bar{r}} + \frac{\bar{u}R^0}{\bar{r}+R^0} \frac{\partial \bar{u}}{\partial \bar{x}} - \frac{\bar{u}\bar{v}}{\bar{r}+R^0} \right) = -\left(\frac{R^0}{\bar{r}+R^0} \right) \frac{\partial \bar{p}}{\partial \bar{x}} + \frac{1}{(\bar{r}+R^0)^2} \frac{\partial}{\partial \bar{r}}$$

$$((\bar{r}+R^0)^2 \bar{\tau}_{\bar{r}\bar{x}}) + \frac{R^0}{\bar{r}+R^0} \frac{\partial \bar{\tau}_{\bar{x}\bar{x}}}{\partial \bar{x}} - \left(\frac{R^0}{\bar{r}+R^0} \right) B_0^2 \sigma \bar{u}. \quad \dots(7)$$

$$\rho C_p \left(\frac{\partial \bar{T}}{\partial \bar{t}} + \bar{v} \frac{\partial \bar{T}}{\partial \bar{r}} + \frac{\bar{u}R^0}{\bar{r}+R^0} \frac{\partial \bar{T}}{\partial \bar{x}} \right) = k_1 \left[\frac{\partial^2 \bar{T}}{\partial \bar{r}^2} + \frac{1}{\bar{r}+R^0} \frac{\partial \bar{T}}{\partial \bar{r}} + \left(\frac{R^0}{\bar{r}+R^0} \right)^2 \frac{\partial^2 \bar{T}}{\partial \bar{x}^2} \right] +$$

$$(\bar{\tau}_{\bar{r}\bar{r}} - \bar{\tau}_{\bar{x}\bar{x}}) \frac{\partial \bar{v}}{\partial \bar{r}} + \bar{\tau}_{\bar{x}\bar{r}} \left(\frac{\partial \bar{u}}{\partial \bar{r}} + \frac{R^0}{\bar{r}+R^0} \frac{\partial \bar{v}}{\partial \bar{x}} - \frac{\bar{u}}{\bar{r}+R^0} \right), \quad \dots(8)$$

$$\frac{\partial \bar{C}}{\partial \bar{t}} + \bar{v} \frac{\partial \bar{C}}{\partial \bar{r}} + \frac{\bar{U}R^0}{\bar{r}+R^0} \frac{\partial \bar{C}}{\partial \bar{x}} = D^0$$

$$\left[\frac{\partial^2 \bar{C}}{\partial \bar{r}^2} + \frac{1}{\bar{r}+R^0} \frac{\partial \bar{C}}{\partial \bar{r}} + \left(\frac{R^0}{\bar{r}+R^0} \right)^2 \frac{\partial^2 \bar{C}}{\partial \bar{x}^2} \right] + \frac{D^0 K_T}{T_m} \left[\frac{\partial^2 \bar{T}}{\partial \bar{r}^2} + \frac{1}{\bar{r}+R^0} \frac{\partial \bar{T}}{\partial \bar{r}} + \left(\frac{R^0}{\bar{r}+R^0} \right)^2 \frac{\partial^2 \bar{T}}{\partial \bar{x}^2} \right] \quad \dots(9)$$

$$\bar{x} = \bar{x} - c\bar{t}, \bar{R} = \bar{r}, \bar{u} = \bar{U} - c, \bar{v} = \bar{V}, \bar{P}(\bar{x}, \bar{r}) = \bar{P}(\bar{X}, \bar{R}, \bar{t}) \quad \dots(10)$$

To simplify the equations (5–8), we introduced the following dimensionless transformation as below:

$$\bar{x} = \lambda \bar{x}, \bar{u} = c\bar{u}, \bar{r} = a\bar{r}, \bar{v} = \delta cV, \bar{t} = \frac{\lambda \bar{t}}{c}, \bar{k}_1 = a\bar{k}_1, \bar{k}_2 = a\bar{k}_2, \delta = \frac{a}{\lambda},$$

$$R^0 = ak, \phi = \frac{b}{a}, \bar{\eta}(T) = \eta_0 \eta(\theta), \theta = \frac{T-T_0}{T_0}, \bar{P} = \frac{P\eta_0 c\lambda}{a^2}, Re = \frac{PCa}{\eta_0}, M^2 = \frac{\sigma a^2 B_0^2}{\eta_0},$$

$$\bar{\tau} = \frac{\tau_0 C}{a}, Pr = \frac{\eta_0 C_p}{K_1}, E_c = \frac{c^2}{C_p T_0}, B_r = P_r \cdot E_c, u = -\frac{\partial \psi}{\partial \bar{r}}, V = \frac{k}{r+k} \frac{\partial \psi}{\partial \bar{x}} \quad \dots(11)$$

where $k, \phi, \eta_0, \bar{P}, Re, M^2, \theta, Ec$ and B_r are the curvature parameter, the implitude ratio, viscosity temperature, pressure Parameter, Reynolds number, Hartman number, temperature, Eckert number and Brinkman number: $\Omega = \frac{\bar{C}-\bar{C}_0}{C_0}, S_r = \frac{PD^0 K_T T_0}{\mu_0 C_0 T_m}, S_c = \frac{\mu_0}{PD^0}$, we will substitute (10) and (11) into equations (5–9) to get the following:

$$\frac{k}{r+k} \frac{\partial u}{\partial \bar{x}} + \frac{\partial v}{\partial \bar{r}} + \frac{v}{r+k} = 0, \quad \dots(12)$$

$$Re \delta \left(\delta^2 \frac{\partial v}{\partial \bar{t}} + \delta^2 v \frac{\partial v}{\partial \bar{r}} + \delta^2 u \frac{k}{(r+k)} \frac{\partial v}{\partial \bar{x}} - \frac{u^2}{(r+k)} \right) \quad \dots(13)$$

$$Re \delta \left(\frac{\partial u}{\partial \bar{t}} + v \frac{\partial u}{\partial \bar{r}} + \frac{ku}{(r+k)} \frac{\partial u}{\partial \bar{x}} + \frac{uv}{(r+k)} \right) = -\frac{k}{(r+k)} \frac{\partial P}{\partial \bar{x}} + \frac{\delta k}{(r+k)} \frac{\partial \tau_{\bar{x}\bar{x}}}{\partial \bar{x}} +$$

$$\frac{1}{(r+k)^2} \frac{\partial}{\partial \bar{r}} ((\bar{r}+k)^2 \tau_{\bar{r}\bar{r}}) - \frac{k^2}{(r+k)^2} M^2 u, \quad \dots(14)$$

$$S_c Re \delta \left(\frac{\partial \Omega}{\partial \bar{t}} + v \frac{\partial \Omega}{\partial \bar{r}} + \frac{ku}{(r+k)} \frac{\partial \Omega}{\partial \bar{x}} \right) = \frac{\partial^2 \Omega}{\partial \bar{r}^2} + \frac{1}{(r+k)} \frac{\partial \Omega}{\partial \bar{r}} + \frac{\delta^2 k^2}{(r+k)^2} \frac{\partial^2 \Omega}{\partial \bar{x}^2} +$$

$$S_c S_r \left[\frac{\partial^2 \theta}{\partial \bar{r}^2} + \frac{1}{r+k} \frac{\partial \theta}{\partial \bar{r}} + \delta^2 \frac{k^2}{(r+k)^2} \frac{\partial^2 \theta}{\partial \bar{x}^2} \right], \quad \dots(15)$$

if we

$$F(\bar{\kappa}, \bar{\mathfrak{k}}) = Q + 2(\kappa(\bar{\kappa}, \bar{\mathfrak{k}}) - 1), \quad \dots(16)$$

$$\text{where} \quad \kappa_1(\kappa)F = \int_{\kappa_2(\kappa)}^{\kappa_1(\kappa)} \frac{\partial \psi}{\partial \gamma} d\gamma = \psi(\kappa_1) - \psi(\kappa_2). \quad \dots(17)$$

Selecting $\psi(\kappa_1) = \frac{F}{2}$ and $\psi(\kappa_2) = -\frac{F}{2}$, A boundary condition in dimensionless stream functions s take a form:

$$\begin{aligned} \psi &= \frac{F}{2}, \frac{\partial \psi}{\partial r} = 0, \theta = 0 \text{ at } r = \kappa_1 = 1 + \phi \cos 2\pi(\kappa + \mathfrak{k}) \\ \psi &= -\frac{F}{2}, \frac{\partial \psi}{\partial r} = 0, \theta = 1 \text{ at } r = \kappa_2 = -1 - \phi \cos 2\pi(\kappa - \mathfrak{k}). \end{aligned} \quad \dots(18)$$

The non-dimensional expressions of averages rise in pressure (ΔP) are:

$$\Delta p = \int_0^1 \frac{\partial P}{\partial \kappa} d\kappa \quad \dots(19)$$

by using the McLaurin series expansion we can write

$$\eta(\theta) = 1 - \alpha\theta \text{ for } \alpha \ll 1 \quad \dots(20)$$

[8]:

3. Perturbation Analysis:

Of course, its not possible to obtain general solutions in an accurate closed form of all the initial values of the parameters appearing in the non-linear equations, so we will work to extend the energy series in terms of the small parameter (δ) (regular perturbation method) and then expand each as below:

$$\psi = \psi_0 + \delta\psi_1, \quad P = p_0 + \delta p_1, \quad \theta = \theta_0 + \delta\theta_1. \quad \dots(21)$$

Now substituting (21) in to equations (13-15), we get:

$$\frac{\partial P}{\partial r} = 0, \quad \dots(22)$$

$$\frac{\partial P}{\partial \kappa} = \frac{r+k}{k} \frac{\partial r}{\partial r} \tau_{r\kappa} + \frac{1}{(r+k)} M^2 \frac{\partial \psi}{\partial r}, \quad \dots(23),$$

$$\tau_{\kappa\kappa} = 0, \tau_{rr} = 0, \tau_{r\kappa} = 2\eta(\theta) \left(-\frac{\partial^2 \psi}{\partial r^2} + \frac{1}{(r+k)} \frac{\partial \psi}{\partial r} \right), \quad \dots(24)$$

$$0 = \frac{\partial^2 \theta}{\partial r^2} + \frac{1}{(r+k)} \frac{\partial \theta}{\partial r} + 2B_r \eta(\theta) \left(-\frac{\partial^2 \psi}{\partial r^2} + \frac{1}{(r+k)} \frac{\partial \psi}{\partial r} \right)^2, \quad \dots(25)$$

$$0 = \frac{\partial^2 \Omega}{\partial r^2} + \frac{1}{r+k} \frac{\partial \Omega}{\partial r} + S_r S_c \left(\frac{\partial^2 \theta}{\partial r^2} - \frac{1}{(r+k)} \frac{\partial \theta}{\partial r} \right) \quad \dots(26)$$

So:

$$\frac{\partial P}{\partial \kappa} = \frac{1}{k(r+k)} \frac{\partial}{\partial r} \left[2(r+k)^2 (1 - \alpha\theta) \left(-\frac{\partial^2 \psi}{\partial r^2} + \frac{1}{(r+k)} \frac{\partial \psi}{\partial r} \right) \right] + \frac{1}{(r+k)} M^2 \frac{\partial \psi}{\partial r} \quad \dots(27)$$

$$0 = \frac{\partial^2 \theta}{\partial r^2} + \frac{1}{r+k} \frac{\partial \theta}{\partial r} + 2B_r (1 - \alpha\theta) \left(-\frac{\partial^2 \psi}{\partial r^2} + \frac{1}{(r+k)} \frac{\partial \psi}{\partial r} \right)^2, \quad \dots(28)$$

$$0 = \frac{\partial^2 \Omega}{\partial r^2} + \frac{1}{r+k} \frac{\partial \Omega}{\partial r} + S_r S_c \left(\frac{\partial^2 \theta}{\partial r^2} - \frac{1}{(r+1)} \frac{\partial \theta}{\partial r} \right), \quad \dots(29)$$

with boundary conditions:

$$\left. \begin{aligned} \psi = \frac{F}{2}, \frac{\partial \psi}{\partial r} = 1, \theta = 0, \Omega = 1 \quad \text{at } r = \kappa_1 \\ \psi = \frac{-F}{2}, \frac{\partial \psi}{\partial r} = 1, \theta = 0, \Omega = 1 \quad \text{at } r = \kappa_2 \end{aligned} \right] \quad \dots(30)$$

3.1 Zero order system

$$\frac{\partial p_0}{\partial \kappa} = \frac{-2(r+k)}{k} \frac{\partial^3 \psi_0}{\partial r^3} - \frac{1}{k} \frac{\partial^2 \psi_0}{\partial r^2} + \frac{1}{k(r+k)} \frac{\partial \psi_0}{\partial r} + \frac{1}{(r+k)} M^2 \frac{\partial \psi_0}{\partial r}, \quad \dots(31)$$

$$0 = \frac{\partial^2 \Omega_0}{\partial r^2} + \frac{\partial \Omega_0}{r+k} \frac{\partial \Omega_0}{\partial r} + S_r S_c \left[\frac{\partial_0 \theta_0}{\partial r^2} + \frac{1}{r+k} \frac{\partial \theta_0}{\partial r} \right] \quad \dots(32)$$

$$\left. \begin{aligned} \psi_0 = \frac{F_0}{2}, \frac{\partial \psi_0}{\partial r} = 1, \theta_0 = 0, \Omega_0 = 0 \quad \text{at } r = \kappa_1 \\ \psi_0 = \frac{-F_0}{2}, \frac{\partial \psi_0}{\partial r} = 1, \theta_0 = 1, \Omega_0 = 1 \quad \text{at } r = \kappa_2 \end{aligned} \right] \quad \dots(33)$$

3.2 First order system

$$\begin{aligned} \frac{\partial p_1}{\partial \kappa} = \frac{-2(r+k)}{k} \frac{\partial^3 \psi_1}{\partial r^3} - \frac{2}{k} \frac{\partial^2 \psi_1}{\partial r^2} + \frac{1}{k(r+k)} \frac{\partial \psi_1}{\partial r} + \frac{(r+k)}{k} \frac{\partial^3 \psi_0}{\partial r^3} + \frac{1}{k} \frac{\partial^2 \psi_0}{\partial r^2} + \\ \frac{(r+k)}{k} \frac{\partial^2 \psi_0}{\partial r^2} - \frac{1}{k(r+k)} \frac{\partial \psi_0}{\partial r} - \frac{1}{k} \frac{\partial \psi_0}{\partial r} + \frac{1}{(r+k)} M^2 \frac{\partial \psi_1}{\partial r} \end{aligned} \quad \dots(34)$$

$$0 = \frac{\partial^2 \Omega_1}{\partial r^2} + \frac{1}{r+k} \frac{\partial \Omega_1}{\partial r} + S_r S_c \left[\frac{\partial^2 \theta_1}{\partial r^2} + \frac{1}{r+k} \frac{\partial \theta_1}{\partial r} \right] \quad \dots(35)$$

$$\left. \begin{aligned} \psi_1 = \frac{F_1}{2}, \frac{\partial \psi_1}{\partial r} = 1, \theta_1 = 0, \Omega_1 = 0 \quad \text{at } r = \kappa_1 \\ \psi_1 = \frac{-F_1}{2}, \frac{\partial \psi_1}{\partial r} = 1, \theta_1 = 1, \Omega_1 = 1 \quad \text{at } r = \kappa_2 \end{aligned} \right] \quad \dots(36)$$

4. Graphical result and discussions

In our paper, a numerical & computational result of a problem for a non-Newtonian, incompressible Walter's - B viscous fluid with variable Viscosity due to its temperature in a Curved Peristaltic channel), were discussed, with effect for the radial magnetic field, the pressure gradient, concentration Field, temperature distribution and pressure rise function, through illustrations of the results. The result was that we used a famous Math program to find out the numbers and illustrations called the Mathematic Program, $\left(\frac{\partial P}{\partial \kappa}\right)$, represents the change in the axial pressure gradient across the walls of the curved channel for peristaltic flow of non -Newtonian Walter's - B fluid, so we study impacts for the parameters $(K, \phi, \delta, a, b^*, d^*, F_0, M)$ on the $\left(\frac{\partial P}{\partial \kappa}\right)$ curve in the graphical Figures 2,3,4,5,6,7,8, and 9. The effect of fluid parameters (k, b, d) , on the pressure gradient profile shown in Figures 3, 7 and 8, when these parameters increase, $\left(\frac{\partial P}{\partial \kappa}\right)$ increases until it reaches a certain value in the center of the curved channel. Now we will record the reaction of $\left(\frac{\partial P}{\partial \kappa}\right)$ with the parameters (δ, M) that are of utmost importance, as we will notice that their increasing values will lead to a decrease in the regression curve as shown in Figures 2, 5 and 6, which

show's that when a quantity arises for the parameter (a) the value of $\left(\frac{\partial p}{\partial \kappa}\right)$, Hereit will decrease correspondingly until it reaches a fixed value, in other words, a relatively large flow can exist without the need for a hypothesis. Large in the middle of the channel and on the contrary is imposed. $\left(\frac{\partial P}{\partial \kappa}\right)$, Large near the curved channel walls to achieve the same flow. in Figure 4, the increasing values of (O), appear, which provide clear resistance to the flow rate at which $\left(\frac{\partial P}{\partial \kappa}\right)$ increases, to ascertain value at the center of the curved channel. Then we drew the shape in Figure 9 for the purpose of analyzing the effect of parameter (F_0) on the $\left(\frac{\partial P}{\partial \kappa}\right)$ file, where the figure indicates an increase $\left(\frac{\partial P}{\partial \kappa}\right)$ near the Lower channel wall, while it decreases in other parts of the channel. Equations (34) & (39) show the temperature distribution expressions far Zeroth and first order solutions. The graphical results in Figures 10,11,12,13,14,15,16, 17, and 18 confirm the complete decreases in temperature distribution at a center for the channel and its walls. An effect of pertinent parameters on the temperature profile can be seen graphically through Figures (10 – 18). Figures 10,13,17, and 18, revealed that increasing values of (δ, M, F_0 , and B) lead to decrease in the temperature distribution. The temperature distribution increases with increase of (k, ϕ, b^* , and d^*) as shown in Figures 11,12,15, and 16, respectively. From Figure 14 of effect of (a), observed that the temperature distribution are not symmetric in curved channel of small value for the parameters (a) & its symmetric in the straight channel of large value for (a). Finally, it can be said that all the drawn graphs of the temperature profile and parameters show the temperature profiles asymmetrically and periodically in the curved channel. The expression for the concentration is given by equations (35) and (40) for Zeroth and first order solution, we took in to account the effect of various parameters on the concentration and the results are shown in the Figures (19-29), The parameters in the concentration file behaves in a manner opposite to the temperature distribution. Tue effects of parameters ($\delta, k, \phi, M, S_r, S_c, a, b^*, d^*, F_0$ and B) on the concentration distribution were taken. in Figures 19,21,22, 23,24,28, and 29, it is observed that the concentration decreases when the parameters ($\delta, \phi, M, S_r, S_c, F_0$, and B) increases, and the converse behavior was obtain of each parameter (k, b, d^*), that were explained in Figures 20,26, and 27, it is worth noting that the reason for the increase in concentration when the parameters increases is due to increase in diffusion Mass, which indicates increase in the concentration profile. Figure 25 of effect of (a), observed that the concentration profile are not symmetric in curved channel of small value for the parameters (a) & its symmetric in the straight channel of large value for (a). We also notice in the curved channel that the concentration distribution graphs have an asymmetric characteristic in this channel.

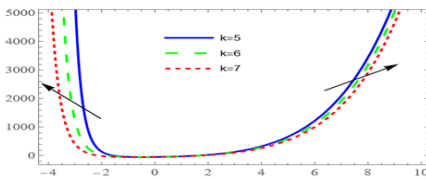


Figure 2
Pressure variation for different (k) values
when $\delta = 2$, $\phi = \frac{\pi}{10}$, $M = 4$, $a = 0.2$,
 $b^* = 0.2$, $d^* = 0.3$, $F_0 = 0.4$

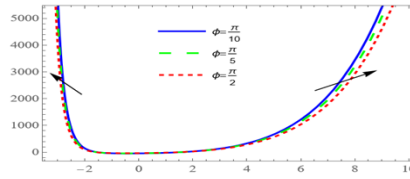


Figure 3
Pressure variation for different (ϕ)
values when $\delta = 2$, $k = 5$, $M = 4$, $a =$
 0.2 , $b^* = 0.2$, $d^* = 0.3$, $F_0 = 0.4$

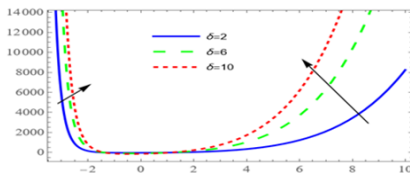


Figure 4
Pressure variation for different (δ) values
when $k = 5$, $\phi = \frac{\pi}{10}$, $M = 4$, $a = 0.2$, $b^* =$
 0.2 , $d^* = 0.3$, $F_0 = 0.4$

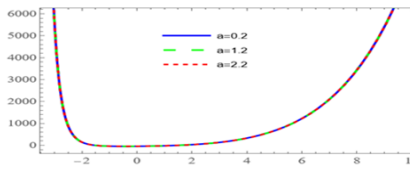


Figure 5
Pressure variation for different (a)
values when $\delta = 2$, $k = 5$, $\phi = \frac{\pi}{10}$, $M =$
 4 , $b^* = 0.2$, $d^* = 0.3$, $F_0 = 0.4$

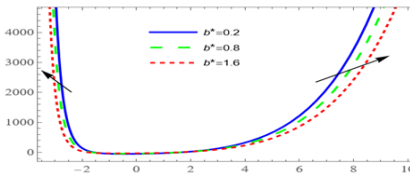


Figure 6
Pressure variation for different (b^*)
values when $\delta = 2$, $k = 5$, $\phi = \frac{\pi}{10}$, $M =$
 4 , $a = 0.2$, $d^* = 0.3$, $F_0 = 0.4$

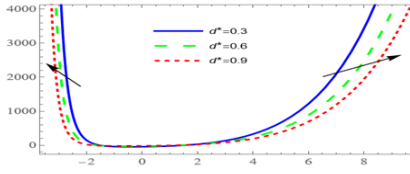


Figure 7
Pressure variation for different (d^*)
values when $\delta = 2$, $k = 5$, $\phi = \frac{\pi}{10}$, $M =$
 4 , $a = 0.2$, $b^* = 0.2$, $F_0 = 0.4$

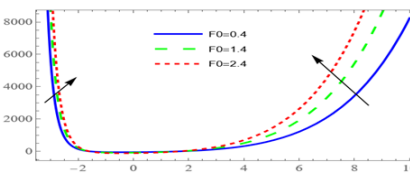


Figure 8
Pressure variation for different (F_0)
values when $\delta = 2$, $k = 5$, $\phi = \frac{\pi}{10}$, $M =$
 4 , $a = 0.2$, $b^* = 0.2$, $d^* = 0.3$

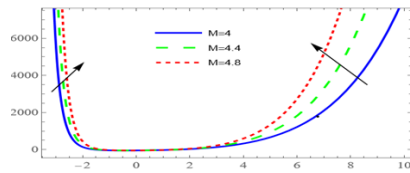
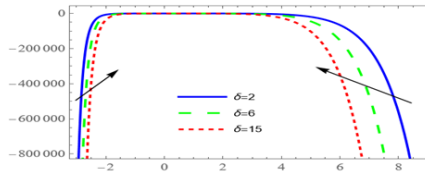
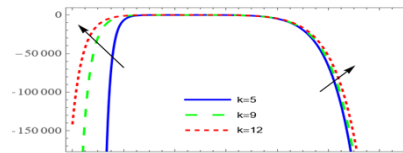


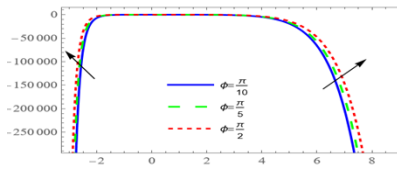
Figure 9
Pressure variation for different (M)
values when $\delta = 2$, $k = 5$, $\phi = \frac{\pi}{10}$, $a =$
 0.2 , $b^* = 0.2$, $d^* = 0.3$, $F_0 = 0.4$

**Figure 10**

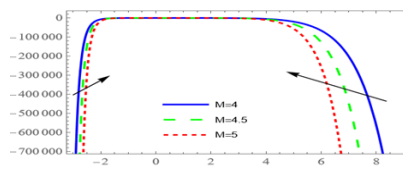
Temperature variation for different (δ) values when $k = 5, \phi = \frac{\pi}{10}, M = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 11**

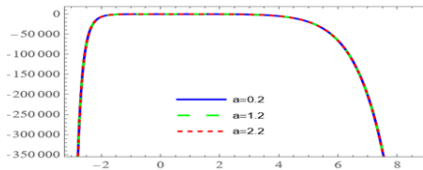
Temperature variation for different (k) values when $\delta = 2, \phi = \frac{\pi}{10}, M = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 12**

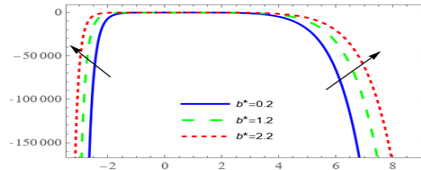
Temperature variation for different (ϕ) values when $\delta = 2, k = 5, M = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 13**

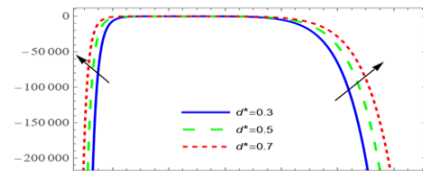
Temperature variation for different (M) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 14**

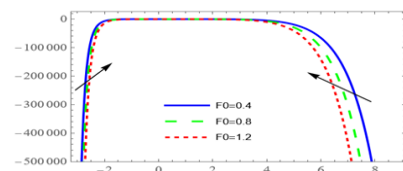
Temperature variation for different (a) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 15**

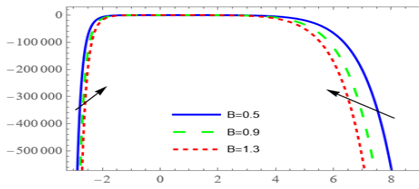
Temperature variation for different (b^*) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, a = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 16**

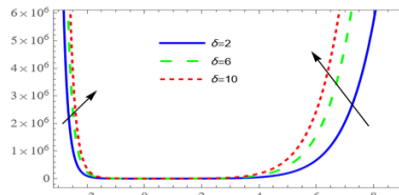
Temperature variation for different (d^*) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, a = 0.2, b^* = 0.2, F_0 = 0.4, B = 0.5$

**Figure 17**

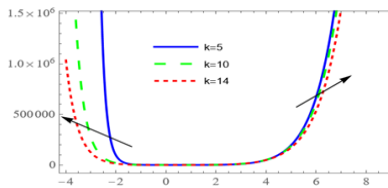
Temperature variation for different (F_0) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, a = 0.2, b^* = 0.2, d^* = 0.3, B = 0.5$

**Figure 18**

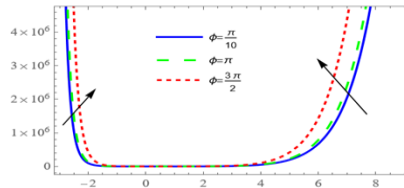
Temperature variation for different (B) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4$

**Figure 19**

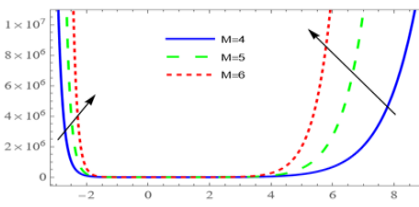
Concentration variation for different (δ) values when $k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 20**

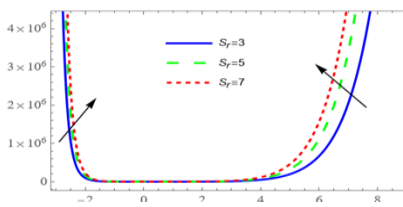
Concentration variation for different (k) values when $\delta = 2, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 21**

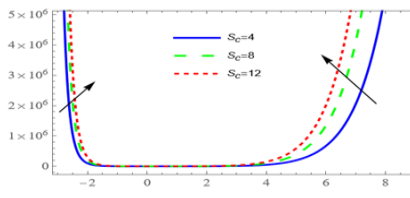
Concentration variation for different (ϕ) values when $\delta = 2, k = 5, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 22**

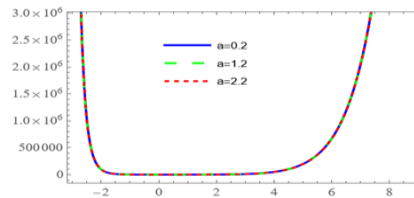
Concentration variation for different (M) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 23**

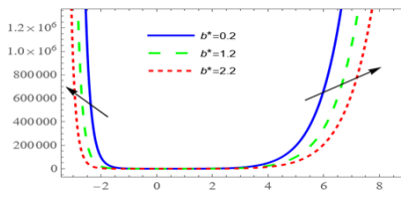
Concentration variation for different (S_r) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F_0 = 0.4, B = 0.5$

**Figure 24**

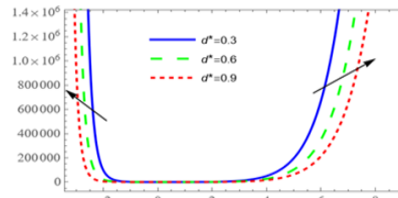
Concentration variation for different (S_c) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, a = 0.2, b^* = 0.2, d^* = 0.3, F0 = 0.4, B = 0.5$

**Figure 25**

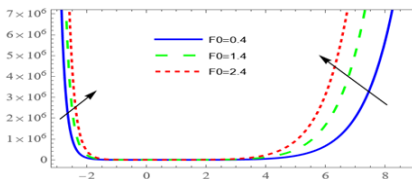
Concentration variation for different (a) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, b^* = 0.2, d^* = 0.3, F0 = 0.4, B = 0.5$

**Figure 26**

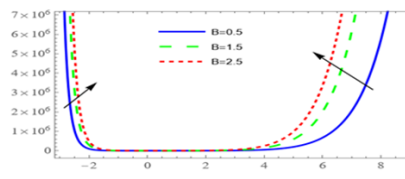
Concentration variation for different (b^*) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, d^* = 0.3, F0 = 0.4, B = 0.5$

**Figure 27**

Concentration variation for different (d^*) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, F0 = 0.4, B = 0.5$

**Figure 28**

Concentration variation for different ($F0$) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, B = 0.5$

**Figure 29**

Concentration variation for different (B) values when $\delta = 2, k = 5, \phi = \frac{\pi}{10}, M = 4, S_r = 3, S_c = 4, a = 0.2, b^* = 0.2, d^* = 0.3, F0 = 0.4$

Conclusion Remark

The presented study aims to investigate the combined effects of temperature distribution, concentration equation, and pressure gradient on peristaltic transport for a viscous, incompressible, and non-Newtonian Walter-B non-Newtonian fluid in a curved peristaltic channel with temperature-varying viscosity. The analytical solution to this problem was obtained under a long wavelength and a small Reynolds number, using the regular perturbation method

for Reynolds's viscosity parameter. All results for different parameter values were analyzed in our work. Observations were concluded below.

- Temperature distribution decreases with increasing (δ , M , F_0 , and B), and this behavior reverses when the parameters (k , ϕ , b^* and d^*) increase.
- Effect of parameters on temperature distribution is somewhat fluctuating.
- The pressure gradient profile effect increases and improves as parameters (k , ϕ , b^* & d^*) increases decreases as parameters (δ , F_0 , and M) increases.
- The effect of the inclusion factor (capacity ratio) on the pressure gradient appears to be quite fluctuating.
- The concentration distribution decreases when the parameters (δ , ϕ , M , S_r , S_c , F_0 and B) increases and the behavior is opposite to the concentration distribution compared to the temperature distribution.
- All temperature distribution and concentration equation appear asymmetric and parabolic in curved channel of small value for curvature parameter (k).

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