Effect of a rotating Frame on Peristalsis Flow of a Walter's B fluid model suspension in a Porous medium, Physical Survey

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ABSTRACT

An effect of arotating frame on peristalsis flow of Waster's B fluid model suspension in apouros metium, physical survey in an asymmetric channel is analyzed. In the asymmetric channel, initially we took into account the condition of non-slip on the channel walls and treated the equations of countinuty, momentum, energy and concentration by using the wave frame work with assumptions of long wavelength and low Reynolds number for the purpose of simplification. The regular turbulence method was used to analyze and study the salient features of the flow properties by solving the constitutive equations for each. From the axial velocity, pressure gradient and temperature distribution, In addition to the concentration equation, and then discuss with explain the behavior of the parameters graphically using the mathematical program "MATHEMATICA" saft ware and obtain practically accurate results**.**

Key words: Rotating frame, Walker's B fluid, Porous mediam, peristalsis flow, pertubation technique.

1. INTRODUCTION

Peristalsis flow is the vital mechanism used to distinguish a progressive wave of region expansion or reduction which spreads above the Length of the walls of channel. Peristaltic stream is an ingrained characteristic of numerous tubiform body part of the human. It is further employed for many industrial enforcement just as corrosive as well as noxious fluids transmit, the blood pumps in heart lung gadget and transport the sanitary fluid. The studies on peristaltsis the flow is widely expanded and developed and several studies, researches on the peristalsis transport [1]–[4]. Rotation effect on peristaltis flow of Walter's B fluid in the porosity space on an asymmetric channel with No-slip condition [5]–[7]. Effect of couple stress with slip condition and rotation on peristaltic flow of a Powell- Eyring fluid with the influence of an inclined asymmetric channel with porous medium ,has been investigated by R. G. Ibraheem and L. Z. Hummady [8]. Abd-Alla and Abo- Dahab [9]studied the rotation effect on peristaltic transport of a Jeffrey fluid in an asymmetric channel with gravity Field. Z. A. Jaafar et al. [10], discussed the impact of couple stress with rotation on Walters , B fluid in porous medium. Abd-Alla et al. [11] investigated Radially Varying magnetic field on the peristaltic flow in a tube with an endoscope under the effect of rotation. Mahmoud et al. [12] investigated the effect of the rotation on wave motion through cylindrical bore in amicropolar porous medium.Abd-Alla et al. [13] discussed the effect of retortion and magnetic field on non-linear peristaltic flow of second-order fluid in an asymmetric channel through a porous medium. Abd-Alla etal. [14] analyzed the effects of an endoscope and rotation on peristaltic flow in atube with long wavelength Saba and Ahmed [15] discussed influence of rotating frame on the peristaltic flow of a Rabinowitsh fluid model in an inclined channel. Many studies deal with the outcome of vatation because of it is significance in fluid mechanics as decorated in industrial fields as well as mechanical engineering besides physicalgical operations, for examples food treatment biochemical operations, biomedical engineering, transfer in polymers, oxygenation, promulgation of chemical feculences and hemodialysis.The investigations with regard to the rotation influences have been detailed in [16]–[18]. There are other attempts to explain the effect of this phenomenon in Refs.[19]–[21] .The sight of this paper was to study the effect of arotating frame on peristalsis flow of a Walter's B fluid model suspension in a porous medium, physical survey in an asymmetric channel. Here, naturally the non-linear governing equations are studies under long wave length assumption with the low Reynolds number to obtain has been done. Closed assertion for axial velocity, pressure gradient, temperature distribution and concentration equation is attained. The impacts of various parameters for this flow are evaluated and graphically presented by applying mathematical program called "MATHEMATICA" soft ware.

3. CONCLUSIONS

It was found in this paper some applications of the notion of differential subordination as it relates to subclasses of univalent functions that use specific convolution as operators. We did examine geometric properties of these kinds of functions, including coefficient bounds, distortion theorem, starlikeness and convexity radii, among others. Extreme points and the integral operator have both been studied.
We investigated a few of the characteristics of variations subordination of analytical univalent functions over an open unit disc as well as deduced specific subordination as well as superordination properties using the characteristics of the broader a byproduct operator. Additionally, it gave insight into geometrical traits like coefficient disparities and Hadamard product characteristics. There were installed certain intriguing findings for derivatives differential subordination as well as superordination of analytical univalent functions. Then, a few findings of variations subordination that involve linear operators have been presented employing the convolution with two linear operators. The convolution operator has been used to deal with a number of leads to over differential subordination within the unit disk with open edges employing broader hypergeometric function.
Through the use of an operator with linearity as well as variations subordination, we arrived at a few conclusions as well as a few sandwich theorems. As an a few convolution as a operators, we as a species provided a few variations subordination programs towards subclasses about univalent functions. Through the application of a straight-line operator, it was possible to achieve certain important outcomes in the variations subordination as well as variations superordination about meromorphic analyzing univalent functions of the second order. Lastly, we provided a few outcomes over 2nd-order differential subordination within the open section disk involving broader hypergeometric function employing the convexity operator.

2. Mathematical Formulation

This paper test an incompressible Walter's B fluid model in a peristalsis transport with effect of arotating frame suspension in a porous media, physical survey. The non-Newtonian. (Walter's B fluid) fills in two dimensional and a symmetric channel of width "$d_1 + d_2$". This flow induced by a sinusoidal wave train of (λ) wavelength, (C) Constant wave speed, $a_1$and $a_2$are amplitudes of the waves, (t) is the time wave.

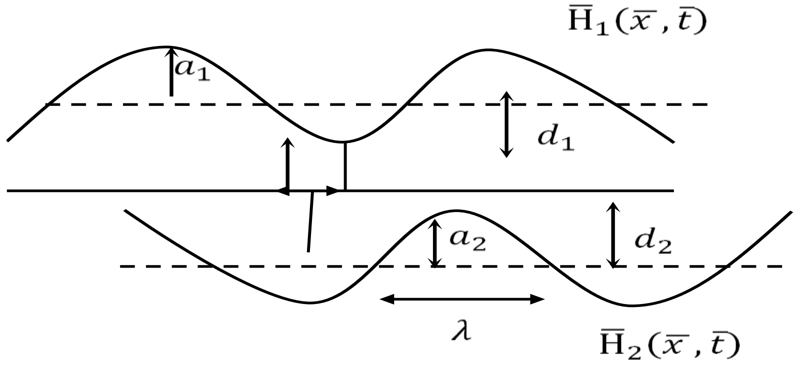

Figure (1): physical sketch

The physical sketch of this problem (Fig-1) represented the geometrical equations of the walls can be expressed as:

$$\bar{H}_1(\bar{x},\bar{t}) = d_1 + a_1 \sin\frac{2\pi}{\lambda}(\bar{x} - c\bar{t})$$

$$\bar{H}_2(\bar{x},\bar{t}) = -d_2 - a_2 \sin\left(\frac{2\pi}{\lambda}(\bar{x} - c\bar{t}) + \theta\right) \quad (1)$$

3. Constitutive Equation

The constitutive equations of two-dimensional for Walter's B fluid flow in a aboratory frame write as follows:

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

$$\rho\left(\frac{\partial\bar{u}}{\partial\bar{E}} + \bar{u}\frac{\partial\bar{u}}{\partial\bar{x}} + \bar{v}\frac{\partial\bar{u}}{\partial\bar{y}}\right) - \rho\Omega\left(\Omega\,\bar{u} + 2\frac{\partial\bar{v}}{\partial\bar{t}}\right) = -\frac{\partial\bar{f}}{\partial x} + \frac{\partial\bar{\tau}_{\bar{x}\bar{x}}}{\partial\bar{x}} + \frac{\partial\bar{\tau}_{\bar{x}\bar{y}}}{\partial y}$$

$$-\sigma B_{\circ}^{2}\cos\beta^{**}\ (\bar{u}\cos\beta^{**} - \bar{v}\sin\beta^{**}) - \frac{\mu}{k_{\circ}}\bar{u} \quad (3)$$

$$\rho\left(\frac{\partial\bar{v}}{\partial\bar{E}} + \bar{u}\frac{\partial\bar{v}}{\partial\bar{x}} + \bar{v}\frac{\partial\bar{v}}{\partial\bar{y}}\right) - \rho\Omega\left(\Omega\,\bar{v} + 2\frac{\partial\bar{u}}{\partial\bar{t}}\right) = -\frac{\partial\bar{f}}{\partial\bar{y}} + \frac{\partial\bar{\tau}_{\bar{x}\bar{y}}}{\partial\bar{x}} + \frac{\partial\bar{\tau}_{\bar{y}\bar{y}}}{\partial\bar{y}}$$

$$+\sigma B_{\circ}^{2}\sin\beta^{**}\ (\bar{u}\cos\beta^{**} - \bar{v}\sin\beta^{**}) - \frac{\mu}{k_{\circ}}\bar{v} \quad (4)$$

$$\rho c_p\left(\frac{\partial\bar{T}}{\partial\bar{t}} + \bar{u}\frac{\partial\bar{T}}{\partial\bar{x}} + \bar{v}\frac{\partial\bar{T}}{\partial\bar{y}}\right) = k^*\left(\frac{\partial\bar{T}}{\partial\bar{t}} + \bar{u}\frac{\partial^2\bar{T}}{\partial\bar{x}^2} + \bar{v}\frac{\partial^2\bar{T}}{\partial\bar{y}^2}\right) +$$

$$\mu\left(\left(\frac{\partial\bar{u}}{\partial\bar{y}} + \frac{\partial\bar{v}}{\partial\bar{x}}\right)^2 + 2\left(\frac{\partial^2\bar{u}}{\partial\bar{x}^2}\right)^2 + 2\left(\frac{\partial^2\bar{v}}{\partial y^2}\right)^2\right) \quad (5)$$

$$\frac{\partial\bar{c}}{\partial\bar{t}} + \bar{u}\frac{\partial\bar{c}}{\partial\bar{x}} + \bar{v}\frac{\partial\bar{c}}{\partial\bar{y}} = D^*\left(\bar{u}\frac{\partial^2\bar{c}}{\partial\bar{x}^2} + \frac{\partial^2\bar{c}}{\partial\bar{y}^2}\right) + \frac{D^*K_T}{T^*}\left(\frac{\partial^2\bar{T}}{\partial\bar{x}^2} + \frac{\partial^2\bar{T}}{\partial\bar{y}^2}\right) \quad (6)$$

The velocity components (U, V) in (X, Y) directions with an associated conditions of the boundary are no slip at the channel walls as:

$$\bar{U} = 0\ ,\ \ \bar{T} = \bar{T}_b\ \ ,\ \ \bar{C} = \bar{C}_b\ \ at\ \ y = H_1$$
$$\bar{U} = 0\ ,\ \ \bar{T} = \bar{T}_\circ\ \ ,\ \ \bar{C} = \bar{C}_\circ\ \ at\ \ y = H_2 \qquad (7)$$

A non-Newtonain Walter's B fluid is externally stratified electrically conducting in the entity of Magnetic field in the direction that makes an angle (β^{**}) with the axis (X) in $x\ y$ −planed.
By Ohm's low, $\mu = \sigma(V \times B_\circ), V = (\bar{u}, \bar{v}, O)$ the velocity vector and $B_\circ = (B_\circ \cos\beta^{**}, B_\circ \sin\beta^{**}, o)$ the magnetic flux density vector, Loren TZ force vector can be formulated as:

$$j \times B_\circ = (-\sigma B_\circ^2 \sin\beta^{**}\,(\bar{u}\sin\ \beta^{**} - \bar{v}\cos\beta^{**}), \sigma B_\circ^2 \cos\beta^{**}\,(\bar{u}\sin\ \beta^{**} - \bar{v}\cos\beta^{**}), 0)$$

In rotating frame we have two terms $\left(\rho\Omega(\Omega\bar{u})\right)$ the centrifugal force and $(2\rho\Omega\bar{u})$ the coriolis force with the constituent equation of Warter's B flavid model is expressed as [21] :

$$\bar{\tau} = 2\mu r - 2L_\circ W_\circ,\ W_\circ = \frac{\partial r}{\partial t} + \mathrm{V}.\nabla r - r\nabla\,\mathrm{V} - (\nabla\,\mathrm{V})^T r \qquad (8)$$

And $\mu = \int_\circ^\infty N(\tau)\,d\tau,\ \ L_\circ = \int_\circ^\infty \tau N(\tau)\,d\tau$ (9)

Where $L_\circ, \eta$, the small shear rate and the short memory coefficient.

$N(\tau)$is the distribution function with relaxation time and $\int_\circ^\infty \tau N(\tau), \mu \geq 2$, are neglected in case of Walter's B fluid model.

$$\bar{\tau}_{\bar{x}\bar{x}} = 2\mu\bar{u}_{\bar{x}} - L_\circ\left(2\bar{u}_{\bar{x}\bar{t}} + 2\bar{u}\bar{u}_{\bar{x}\bar{x}} + 2\bar{v}\bar{u}_{\bar{x}\bar{y}} - 2\bar{v}_x\bar{v}_y - 2\bar{v}_{\bar{x}}^2 - 4\bar{u}_{\bar{x}}^2\right)$$
$$\bar{\tau}_{\bar{y}\bar{y}} = 2\mu\bar{v}_{\bar{y}} - L_\circ\left(2\bar{v}_{\bar{y}\bar{t}} + 2\bar{u}\bar{v}_{\bar{y}\bar{x}} + 2\bar{v}\bar{v}_{\bar{y}\bar{y}} - 2\bar{u}_{\bar{y}}^2 - 4\bar{v}_{\bar{y}}^2 - 2\bar{u}_{\bar{y}}\bar{v}_{\bar{x}}\right)$$
$$\bar{\tau}_{\bar{x}\bar{y}} = \bar{\tau}_{\bar{y}\bar{x}} = \mu\left(\bar{u}_{\bar{y}} + \bar{v}_{\bar{x}}\right) - L_\circ\begin{pmatrix}\bar{u}_{\bar{y}\bar{t}} + \bar{v}_{\bar{x}\bar{t}} + \bar{u}\bar{u}_{\bar{y}\bar{x}} + \bar{u}\bar{v}_{\bar{x}\bar{x}} + \bar{v}\bar{u}_{\bar{y}\bar{y}} + \\ v\bar{v}_{\bar{x}\bar{y}} - 3\bar{u}_{\bar{y}}\bar{u}_{\bar{x}} - 3\bar{v}_{\bar{x}}\bar{v}_{\bar{y}} - \bar{v}_{\bar{y}}\bar{u}_{\bar{y}} - \bar{u}_x\bar{v}_{\bar{x}}\end{pmatrix} \qquad (10)$$

Now assume the motion peristalsis steady by using the labortory frame which is given as:

$$\bar{x} = \bar{x} - \bar{c}\bar{t}\ ,\bar{y} = \bar{Y}\ ,\bar{u} = \bar{u} - \bar{c}\ ,\bar{v} = \bar{v}\ ,\bar{P}(\bar{x},\bar{y}) = \bar{P}(\bar{x},\bar{y},\bar{t}) \qquad (11)$$

There after we introduce dimensionaless quantities as follows:

$$x = \frac{\bar{x}}{\lambda}\ ,y\frac{\bar{y}}{d}\ ,u = \frac{\bar{u}}{c}\ ,v = \frac{\bar{v}}{sc}\ \ ,\delta = \frac{d_1}{\lambda}\ \ ,t = \frac{c\bar{t}}{\lambda}\ \ ,P = \frac{\bar{p}d_1^2}{\mu c\lambda}\ ,h_1 = \frac{\bar{H}_1}{d_1}\ ,h_2 = \frac{\bar{H}_2}{d_2}\ ,$$

$$k_\circ = \frac{\bar{k}_\circ}{d_1^2}\ ,H_a = d_1 B_\circ\sqrt{\frac{\sigma}{\mu}}\ \ ,R_e = \frac{pcd_1}{\mu}\ ,S_c = \frac{\mu}{\lambda\rho}\ \ ,S_r = \frac{\rho D^* k_T(\bar{T}_b - \bar{T}_\circ)}{T^*(\bar{C}_b - \bar{C}_\circ)}\ ,$$

$$\theta = \frac{\bar{T}\ \ -\bar{T}_\circ}{\bar{T}_b - \bar{T}_\circ}\ ,\ \ \beta^{**} = \frac{a_1}{d_1}\ ,\qquad E_c = \frac{C^2}{C_p(\bar{T}\ \ -\bar{T}_\circ)}\ ,\ \ P_r = \frac{C_p\mu}{k^*}\ ,\ \ \bar{t} = \frac{\tau c\mu}{d_1}\ ,\ \ d = \frac{d_2}{d_1}$$

$$d=\frac{d_2}{d_1}\ ,\ b=\frac{a_2}{d_2}\ ,\ \Omega=\frac{\bar{\Omega}d_1^2}{\mu} \tag{12}$$

In light of eqs.(11)-(12), and their substitution in the eqs.(2-6), we conclude the following:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{13}$$

$$R_e\delta\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)-\frac{\rho\Omega^2 d_1^2}{\mu}u=-\frac{\partial f}{\partial x}+\delta\frac{\partial \tau_{xx}}{\partial x}+\frac{\partial \tau_{xy}}{\partial y}-H_a^2\cos\beta^{**}\left(u\cos\beta^{**}-vS\sin\beta^{**}\right)-\frac{u}{k} \tag{14}$$

$$R_e\left(\delta^2 u\frac{\partial v}{\partial x}+\delta^2\frac{\partial v}{\partial y}\right)-\frac{\rho\Omega^2 d_1^2}{\mu}v\delta=-\frac{\partial f}{\delta dy}+\delta\frac{\partial \tau_{xy}}{\partial x}+\frac{\partial \tau_{yy}}{\partial y}-H_a^2\sin\beta^{**}\left(u\cos\beta^{**}-vS\sin\beta^{**}\right)-\frac{v}{k} \tag{15}$$

$$R_e\delta\left(u\frac{\partial\theta}{\partial x}+V\frac{\partial\theta}{\partial y}\right)=\frac{1}{P_r}\left(\delta^2\frac{\partial^2\theta}{\partial x^2}+\frac{\partial^2\theta}{\partial y^2}\right)+E_C\left(\left(\frac{\partial u}{\partial y}+\delta^2\frac{\partial v}{\partial x}\right)^2 2\delta^2\left(\frac{\partial^2 u}{\partial x^2}\right)^2+2\delta^2\left(\frac{\partial^2 v}{\partial y^2}\right)\right) \tag{16}$$

$$R_e\left(\delta(u+1)\frac{\partial\Omega}{\partial x}+\delta V\frac{\partial\Omega}{\partial y}\right)=\frac{1}{Sc}\left(\delta^2\frac{\partial^2\Omega}{\partial x^2}+\frac{\partial^2\Omega}{\partial y^2}\right)+S_r\left(\delta^2\frac{\partial^2\theta}{\partial x^2}+\frac{\partial^2\theta}{\partial y^2}\right) \tag{17}$$

$$U=-1\ ,\ T=T_b\ ,\ C=C_1\ \ at\ \ y=h_1$$
$$U=-1\ ,\ T=T_\circ\ ,\ C=C_\circ\ \ at\ \ y=h_2 \tag{18}$$

After simplify and using $u=\psi_y,\ v=-\psi_x$ we get:

$$R_e\delta\left(\psi_y\frac{\partial}{\partial x}+\psi_x\frac{\partial}{\partial y}\right)\nabla^2\psi+\frac{\rho\Omega^2 d_1^2 S\delta^2}{\mu}\left(\psi_x-\psi_y\right)$$
$$=\delta\left(\frac{\partial^2}{\partial x\partial y}\left(\tau_{xx}-\tau_{yy}\right)\right)+\left(\frac{\partial^2}{\partial y^2}+\delta^2\frac{\partial^2}{\partial x^2}\right)\tau_{xy}-H_a^2\cos\beta^{**}\frac{\partial^2\psi}{\partial y^2}+\delta^2 H_a^2\sin\beta^{**}$$
$$\frac{\partial^2\psi}{\partial x^2}-\delta H_a^2\cos\beta^{**}\sin\beta^{**}\psi_{xy}-\frac{1}{k}\left(\psi_{yy}-S\psi_{xx}\right) \tag{19}$$

Where $\nabla^2=\delta^2\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}$

$$R_e\delta\left(\psi_y\frac{\partial\theta}{\partial x}+\psi_x\frac{\partial\theta}{\partial y}\right)=\frac{1}{P_r}\left(\delta^2\frac{\partial^2\theta}{\partial x^2}+\frac{\partial^2\theta}{\partial y^2}\right)+E_C\left(\left(\frac{\partial\psi_y}{\partial y}-\delta^2\frac{\partial\psi_x}{\partial x}\right)^2 2\delta^2\left(\frac{\partial^2\psi_y}{\partial x^2}\right)^2-2\delta^2\left(\frac{\partial^2\psi_x}{\partial y^2}\right)\right) \tag{20}$$

$$R_e\left(\delta(\psi_y+1)\frac{\partial\Omega}{\partial x}+\delta\psi_x\frac{\partial\Omega}{\partial y}\right)=\frac{1}{Sc}\left(\delta^2\frac{\partial^2\Omega}{\partial x^2}+\frac{\partial^2\Omega}{\partial y^2}\right)+S_r\left(\delta^2\frac{\partial^2\theta}{\partial x^2}+\frac{\partial^2\theta}{\partial y^2}\right) \tag{21}$$

The dimensionaless boundary conditions in wave frame:

$$\psi=\frac{F}{2}\ ,\ \theta=1\ ,\ \Omega=1\ \ at\ \ y=h_1$$
$$\psi=\frac{F}{2}\ ,\ \theta=0\ ,\ \Omega=0\ \ at\ \ y=h_2 \tag{22}$$

$$\frac{\partial\psi}{\partial y}=-1 at\ \ y=h_1\ and\ at\ \ y=h_2$$

when we use the laboratory frame Q = $\int_{h_2}^{h_1}(u+1)\,dy$ the mean flow rate is related to F by:

$$Q = F + d + 1 \tag{23}$$

Also $h_1(x) = 1 + a \sin x$

$$h_2(x) = -d - b \sin(x + \emptyset) \tag{24}$$

When $\emptyset$, a , b and d, satisfy the relation

$$a^2 + b^2 + 2ab \cos \emptyset \leq (1 + d)^2 \tag{25}$$

4. Exact solution

From eq. (19), which is non-linear with difficultness, then we solve it by perturbation method and expand as:

$$\psi = \psi_\circ + \delta\, \psi_1 + \cdots\cdots$$
$$P = P_\circ + \delta P_1 + \cdots\cdots$$
$$\theta = \theta_\circ + \delta\theta_1 + \cdots\cdots \tag{26}$$
$$\Omega = \Omega_\circ + \delta\Omega_1 + \cdots\cdots$$

5. Zero order Solution

$$\frac{\partial^2 \tau_{\circ xy}}{\partial y^2} - R_\circ \psi_{\circ yy} = 0$$

Where $R_\circ = H_a^2 cos^2 \beta^{**} + \frac{1}{k_\circ}$ (27)

$$\frac{\partial p_\circ}{\partial x} = \frac{\rho \Omega^2 d_1^2}{\mu} \psi_{\circ y} + \frac{\partial \tau_{\circ xy}}{dy} - R_\circ(\psi_{\circ y} - 1) \tag{28}$$

$$o = \psi_{\circ yyyy} - \psi_{\circ yy} N_\circ$$

Where $N_\circ = \frac{\rho \Omega^2 d_1^2}{\mu} + R_\circ$ (29)

$$\frac{\partial p_\circ}{\partial y} = 0 \tag{30}$$

$$\frac{\partial^2 \theta}{\partial y^2} = -B_r \left(\frac{\partial \psi_{\circ y}}{\partial y}\right)^2$$

Where $B_r = P_r E_C$ (31)

$$\frac{\partial^2 \Omega}{\partial y^2} = -S_C S_r \frac{\partial^2 \theta}{\partial y^2} \tag{32}$$

$$\tau_{\circ xy} = \psi_{\circ yy} \ , \quad \tau_{\circ xx} = 0 \ , \quad \tau_{\circ yy} = 2k\psi_{\circ yy}^2 \tag{33}$$

$$\psi_\circ = \frac{F_\circ}{2} \ , \quad \theta_\circ = 1 \ , \quad \Omega_\circ = 1 \ \ at \ \ y = h_1$$
$$\psi_\circ = -\frac{F_\circ}{2} \ , \quad \theta_\circ = 0 \ , \quad \Omega_\circ = 0 \ \ at \ \ y = h_2 \tag{34}$$

$$\frac{\partial \psi_\circ}{\partial y} = -1 at \;\; y = h_1 \; and \; at \;\; y = h_2$$

6. First order Solution

Replace eq.(26) in eq.(19) and (20), obtain:

$$\boldsymbol{R_e}\left(\boldsymbol{\psi_{\circ y}\psi_{\circ yyx}} - \boldsymbol{\psi_{\circ x}\psi_{\circ yyy}}\right) - \boldsymbol{N_\circ \psi_{1yy}} = \frac{\partial^2}{\partial x \partial y}\boldsymbol{\tau_{\circ yy}} + \frac{\partial^2}{\partial y^2}\boldsymbol{\tau_{1xy}} - \boldsymbol{H_a^2 \cos\beta^{**}} \left(\psi_{1yy} + \sin\beta^{**}\psi_{\circ xy}\right) - \frac{1}{k}\left(\psi_{\circ yy} - \psi_{1yy}\right) \text{ where } N_\circ = \frac{\rho\Omega^2 d_1^2}{\mu} \tag{35}$$

$$\frac{\partial P_1}{\partial x} = \frac{\partial}{\partial y}\tau_{1xy} - R_\circ(\psi_{1y} - 1) + \psi_o \sin\beta^{**} - R_e\left(\psi_{\circ y}\psi_{\circ yx} - \psi_{\circ x}\psi_{\circ yy}\right) + N_\circ \psi_{1y} \tag{36}$$

$$\frac{\partial^2\theta}{\partial y^2} = -B_r\left(\frac{\partial \psi_{1y}}{\partial y}\right)^2 \text{ Where } B_r = P_r E_C \tag{37}$$

$$\frac{\partial^2\Omega}{\partial y^2} = -S_C S_r \frac{\partial^2\theta}{\partial y^2} \tag{38}$$

$$\left.\begin{aligned} &\tau_{1xy} = \psi_{1yy} - k\left(\psi_{\circ y}\psi_{\circ xyy} - \psi_{\circ x}\psi_{\circ yyy} - 2\psi_{\circ xy}\psi_{\circ yy}\right) \\ &\psi_{1xx} = 2\psi_{\circ xy} \\ &\psi_{1yy} = -2\psi_{\circ xy} + 2k\psi_{1yy}^2 \end{aligned}\right] \tag{39}$$

$$\left.\begin{aligned} &\psi_1 = \frac{F_1}{2}\;, \;\; \theta_1 = 1 \;\;, \;\; \Omega_1 = 1 \;\; at \;\; y = h_1 \\ &\psi_1 = -\frac{F_\circ}{2}\;, \;\; \theta_1 = 0 \;\;, \;\; \Omega_1 = 0 \;\; at \;\; y = h_2 \\ &\frac{\partial \psi_1}{\partial y} = -1 at \;\; y = h_1 \; and \; at \;\; y = h_2 \end{aligned}\right] \tag{40}$$

7.Discussions and Graphical

To study the influnce of physical Parameters such as (Ω, H_a, d_1, k,μ, ρ,β^* ,E_c,P_r,Φ,a, b, S_c, S_r, $F_\circ$) and F_1 we have plotted the pressure rise profile (∇P) and concentration distribubion in figures (2 - 20) , all figures are plotted for the values Ω = 6 , $H_a = 0.1$, $d_1 = 0.1$, $k = 1.5$ μ = 0.8 , ρ = 0.6 ,β^* =2.5, E_c=1,$P_r = 3$,d =2.5, $a = 0.4$,, b = 0.6, S_C=0.5,$F_\circ$=0.9 and F_1= 0.5 using "MATHEMATECA" soft ware. using the most important values of the parameters affecting the solution of the equations of the problem, the profile of the pressure rise was defined according to the order of the values (Ω, H_a, d_1, k,μ, ρ) and which were accurately described in the graphical figures (2,3,4,5,6,7). Using the Mathematica software, the variation of the pressure rise for cach wavelength is explained in agreement with the average flow rate of the asymmetric channel under the influence of the periodic frame on the peristalsis flow of the non-Newtonian Walter's B model suspended in a porous medium, for the relevant parameters, the entir pumping area consists of three main areas. The First is called the retrograde pumping $\Delta P > 0\& \ Q < 0$ and the second is the co-pumping $\Delta P < 0\& \ Q < 0$, and the third area is called augmented pumping $\Delta P < 0\& \ Q > 0$.

Figures (2,4,5) highlight the variation of the pressure rise for different values of the parameters $(\Omega,\ H_a,\ d_1)$ as the pressure rise increases with increasing $(\Omega,\ H_a,\ d_1)$ in the retrograde pumping and co-pumping area on the contrary in the augmented pumping area. Figures (3 and 6) are plotted to see the impact of K and μ on the pressure rise, it's observed that decreases in retrograde pum ping area and co-Pumping area with an increase in augmented pumping area. The opposite thing happens with ρ increasing as shown in figure (7).The graphical nouits for concentration profile are illustrated in figures (8-20) figure (18) explain that the effect of parameters on the concentration profile it is observed that the concentration distribution exhibits oscillating behavior with an increase in the (F_1), from figure (12) the concentration distribution decreases in the central area and right channel wall, but incenses near the left channel wall for increasing in (ϕ) while the opposite behavior is occurring with the increase in (a), as shown in figure (13), figures (8,9,10,11) deduced that the concentration decreases by increasing in($E_c, P_r, d_1)$ $and(N)$.

Figures (14,15,16) and (17) shown that the concanbehan distribution decreases near the channel walls and then gradually disapear as there is no effect on the concentration distribution to the rest of the channel with an increase in (b, S_C, S_r) and $F_\circ$.

7.1. Pressure rise

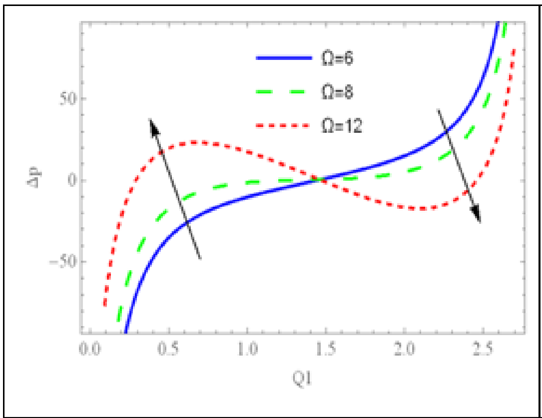

Figure (2)Effect of the Rotation Parameter (Ω) on $\Delta P(K \to 1.5; \phi \to 0.3, Ha \to 0.1, a \to 4, b \to 4, d^* \to 0.01, F0 \to 0.3, F1 \to 0, d1 \to 0.1, \mu \to 0.5, \rho \to 0.6, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

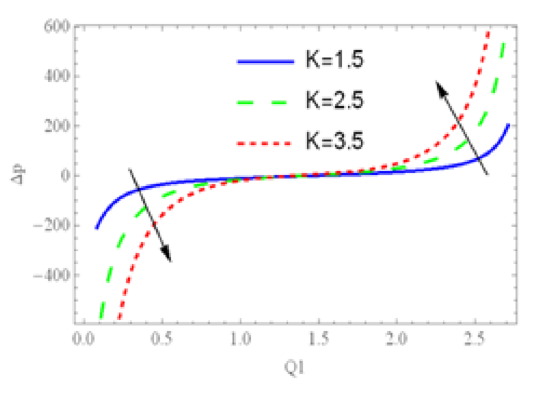

Figure (3)Effect of the Permeability Parameter (k) on $\Delta P(\phi \to 0.3, Ha \to 0.1, a \to 4, b \to 4, d^* \to 0.01, F0 \to 0.3, F1 \to 0, \Omega \to 6, d1 \to 0.1, \mu \to 0.5, \rho \to 0.6, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

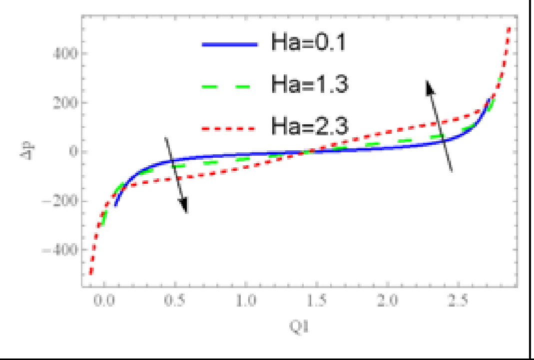

Figure (4)Effect of the Hartman Number (H_a) on $\Delta P(K \to 1.5, \phi \to 0.3, a \to 4, b \to 4, d^* \to 0.01, F0 \to 0.3, F1 \to 0, \Omega \to 6, d1 \to 0.1, \mu \to 0.5, \rho \to 0.6, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

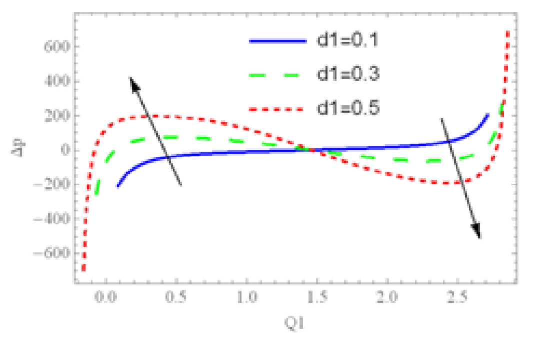

Figure (5)Effect of the Width of Channal (d_1) on $\Delta P(K \to 1.5, \phi \to 0.3, Ha \to 0.1, a \to 4, b \to 4, d^* \to 0.01, F0 \to 0.3, F1 \to 0, \Omega \to 6, \mu \to 0.5, \rho \to 0.6, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

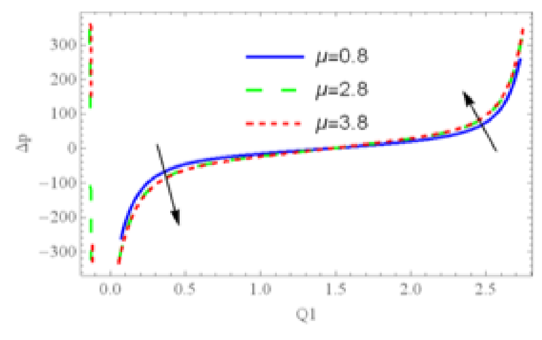

Figure (6)Effect of the Viscosity Parameter (μ) on $\Delta P(K \to 1.5, \phi \to 0.3, \mathrm{Ha} \to 0.1, a \to 4, b \to 4, d^* \to 0.01, \mathrm{F0} \to 0.3, \mathrm{F1} \to 0, \Omega \to 6, \mathrm{d1} \to 0.1, \rho \to 0.6, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

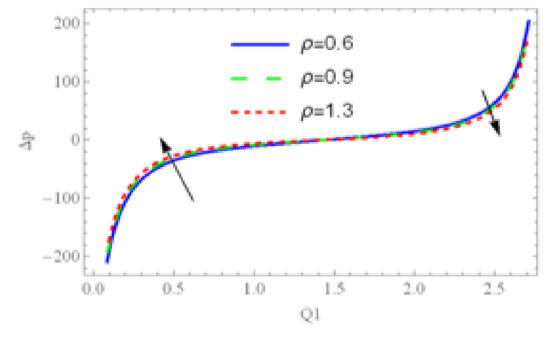

Figure (7)Effect of the Density Parameter (ρ) on $\Delta P(K \to 1.5, \phi \to 0.3, \mathrm{Ha} \to 0.1, a \to 4, b \to 4, d^* \to 0.01, \mathrm{F0} \to 0.3, \mathrm{F1} \to 0, \Omega \to 6, \mathrm{d1} \to 0.1, \mu \to 0.5, Q \to 1.5, \beta^* \to 0.4, y \to 0.001)$

.2. Concentration:

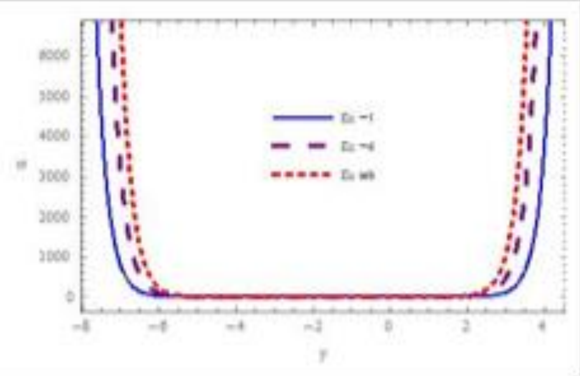

Figure (8)Effect of the Eckert Number (E_C) on $\Omega(\mathrm{Ha} \to 4, \beta^* \to 2.5, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

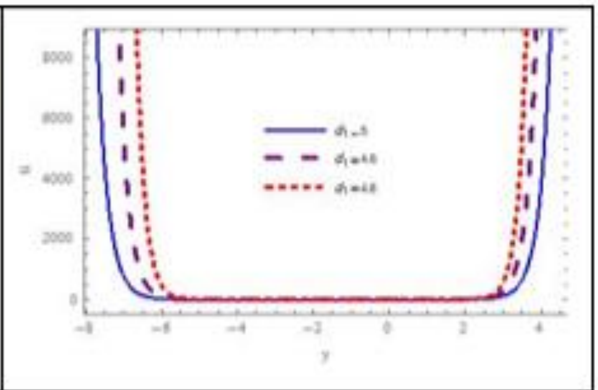

Figure (9)Effect of the Width of the channel Number ($\mathbf{d_1}$) on $\Omega(\mathrm{Ha} \to 4, \beta^* \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

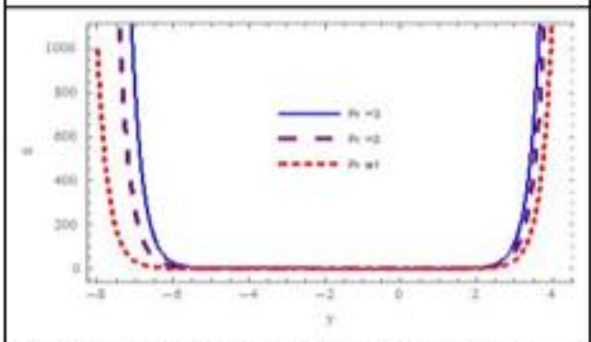

Figure (10)Effect of the Prandtl Number (p_r) on $\Omega(\mathrm{Ha} \to 4, \beta^* \to 2.5, \mathrm{Ec} \to 1, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

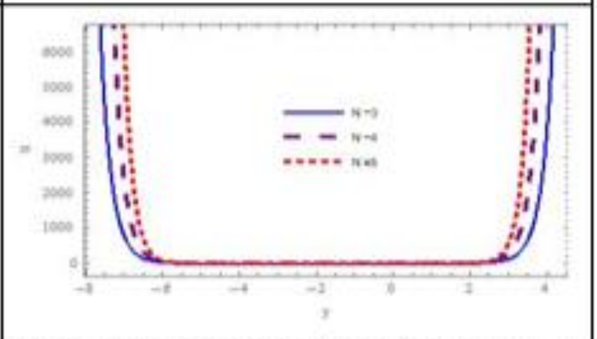

Figure (11)Effect of the Law Number (N) on $\Omega(\mathrm{Ha} \to 4, \beta^* \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

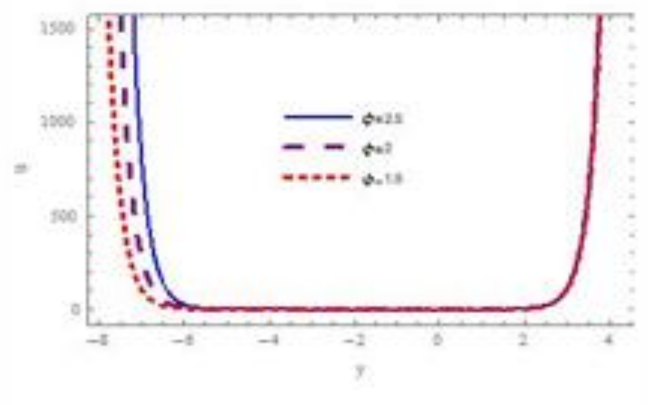

Figure (12)Effect of the Implitude Ratio Number (ϕ) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

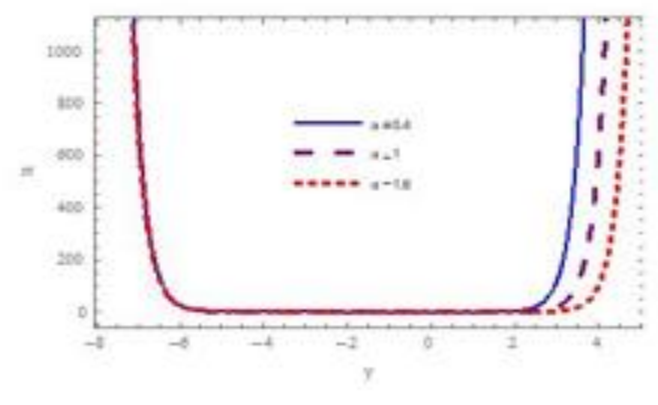

Figure (13)Effect of the Amplitude of the wave Number (a) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

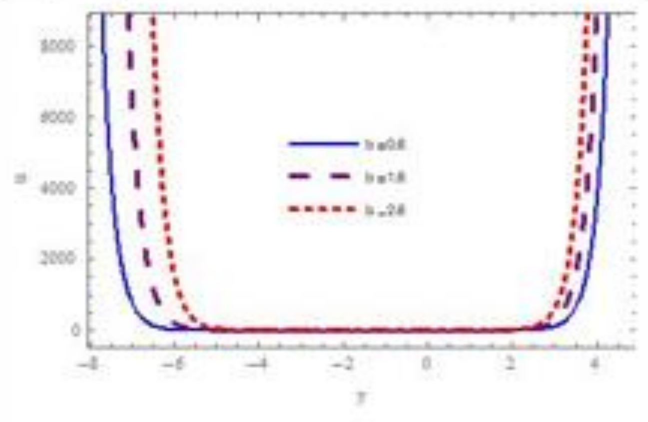

Figure (14)Effect of the Amplitude of the wave Number (b) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, S_c \to 0.5, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

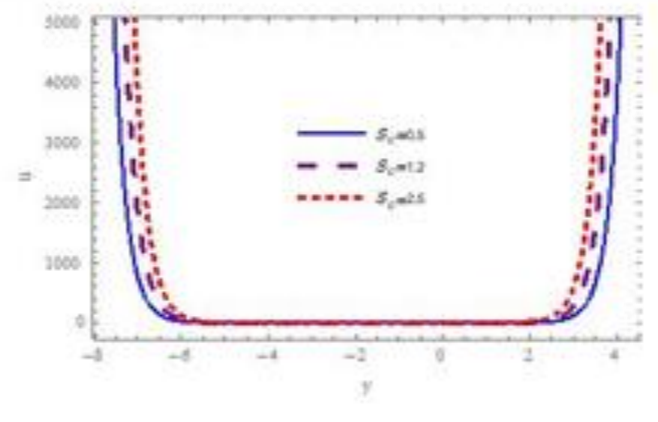

Figure (15)Effect of the Schmidt Number (S_c) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_r \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

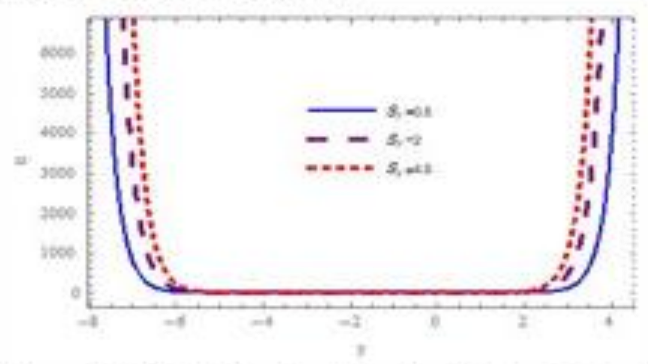

Figure (16)Effect of the Soret Number (S_1) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, \mathrm{F0} \to 0.9, \mathrm{F1} \to 0.5, x \to 1)$

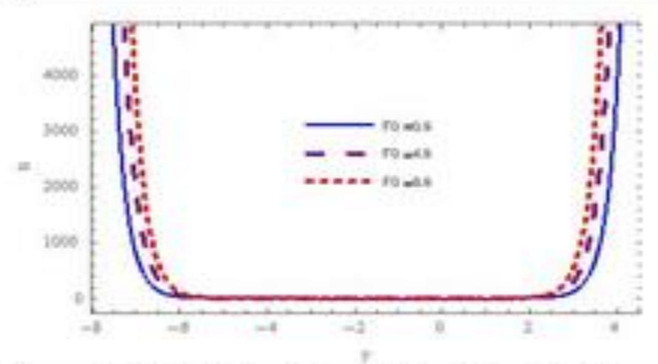

Figure (17)Effect of the Rate of Valume Flow Number (F_0) on $\Omega(\mathrm{Ha} \to 4, \beta^{*} \to 2.5, \mathrm{Ec} \to 1, \mathrm{Pr} \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, \mathrm{F1} \to 0.5, x \to 1)$

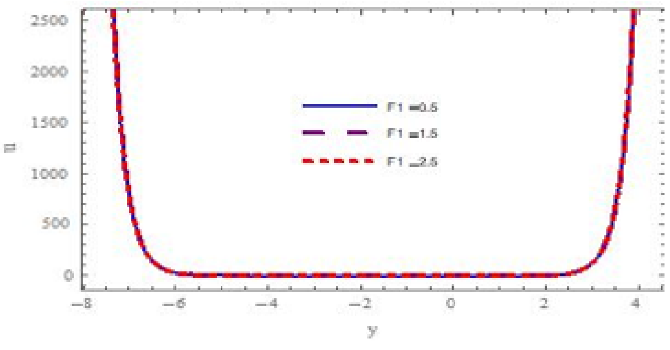

Figure (18)Effect of the Rate of Valume Flow Number (F_1) on $\Omega(Ha \to 4, \beta^* \to 2.5, Ec \to 1, Pr \to 3, d_1 \to 5, N \to 3, \phi \to 2.5, a \to 0.4, b \to 0.6, S_c \to 0.5, S_r \to 0.5, F0 \to 0.9, x \to 1)$

8. Conclusions

The influence of arotating frame on peristalsis flow of Walter's B fluid model suspension in a porous medium in asymmetric channel is investigated under low Reynolds number and long wavelength. The flow is considered in two-dimensional, non-linear partial differential equation was solved by using perturbation technque, some of interesting conclusions are Summarized as follows:

- The impact of various parameters on the pressure rise are different for different pumping area.
- Opposite behavior for pressure rise profile is noticed compared to concentration distribution.
- Prosure rise is decreasing function of the parameters (K and μ) and the opposite thing happens with parameter (ρ).
- Concentration distribution increases in the presence of (ϕ) near the left channel wall while the opposite behavior is occurring with increase of (a).
- Concentration distribution decreases in the presence (b, S_C, S_r) and $F_\circ$ near the channel walls and then gradually disapper as there is no effect on the concentration distribution to the rest of the channel with an increse in this parameter.

9. Reference

[1] A. K. Hage and L. Z. Hummady, "Influence of inclined magnetic field and heat transfer on peristaltic transfer Powell-Eyring fluid in asymmetric channel and porous medium," *Int. J. Nonlinear Anal. Appl.*, vol. 13, no. 2, pp. 631–642, 2022.

[2] A. M. Abdulhadi and A. H. Al-Hadad, "Effects of rotation and MHD on the Nonlinear Peristaltic Flow of a Jeffery Fluid in an Asymmetric Channel through a Porous Medium," *Iraqi J. Sci.*, vol. 57, no. 1A, pp. 223–240, 2016.

[3] S. A. Abdulla and L. Z. Hummadya, "Inclined magnetic field and heat transfer of asymmetric and Porous Medium Channel on hyperbolic tangent peristaltic flow," *Int. J. Nonlinear Anal. Appl.*, vol. 12, no. 2, pp. 2359–2371, 2021.

[4] F. A. Adnan and A. M. A. Hadi, “Effect of an inclined magnetic field on peristaltic flow of Bingham plastic fluid in an inclined symmetric channel with slip conditions,” *Iraqi J. Sci.*, pp. 1551–1574, 2019.

[5] A. M. Abdulhadi and T. S. Ahmed, “Effect of magnetic field on peristaltic flow of Walters’ B fluid through a porous medium in a tapered asymmetric channel,” *J. Adv. Math.*, vol. 1, no. 12, pp. 6889–6893, 2017.

[6] T. S. Alshareef, “Impress of rotation and an inclined MHD on waveform motion of the non-Newtonian fluid through porous canal,” in *Journal of Physics: Conference Series*, 2020, vol. 1591, no. 1, p. 12061.

[7] M. I. Khan, S. U. Khan, M. Jameel, Y.-M. Chu, I. Tlili, and S. Kadry, “Significance of temperature-dependent viscosity and thermal conductivity of Walter’s B nanoliquid when sinusodal wall and motile microorganisms density are significant,” *Surfaces and Interfaces*, vol. 22, p. 100849, 2021.

[8] R. G. Ibraheem and L. Z. Hummady, “Effect of Couple-stress with Slip Condtion and Rotation on Peristaltic Flow of a Powell-Eyring Fluid with the Influence of an Inclined Asymmetric Channel with Porous Medium,” *J. Basic Sci.*, vol. 10, no. 17, 2023.

[9] A. M. Abd-Alla and S. M. Abo-Dahab, “Rotation effect on peristaltic transport of a Jeffrey fluid in an asymmetric channel with gravity field,” *Alexandria Eng. J.*, vol. 55, no. 2, pp. 1725–1735, 2016.

[10] Z. A. Jaafar, M. H. Thawi, and L. Z. Hummady, “Impact of Couple Stress with Rotation on Walters , B Fluid in Porous Medium,” pp. 189–201, 2023.

[11] A. M. Abd-Alla, S. M. Abo-Dahab, and M. M. Albalawi, “Radially varying magnetic field on the peristaltic flow in a tube with an endoscope under the effect of rotation,” *J. Comput. Theor. Nanosci.*, vol. 12, no. 10, pp. 3066–3075, 2015.

[12] S. R. Mahmoud, A. M. Abd-Alla, and M. A. El-Sheikh, “Effect of the rotation on wave motion through cylindrical bore in a micropolar porous medium,” *Int. J. Mod. Phys. B*, vol. 25, no. 20, pp. 2713–2728, 2011.

[13] A. M. Abd-Alla, S. M. Abo-Dahab, and H. D. El-Shahrany, “Effects of rotation and magnetic field on the nonlinear peristaltic flow of a second-order fluid in an asymmetric channel through a porous medium,” *Chinese Phys. B*, vol. 22, no. 7, p. 74702, 2013.

[14] A. M. Abd-Alla, S. M. Abo-Dahab, and H. D. El-Shahrany, “Effects of an endoscope and rotation on peristaltic flow in a tube with long wavelength,” *J. Comput. Theor. Nanosci.*, vol. 11, no. 4, pp. 1055–1068, 2014.

[15] S. S. Hasen and A. M. Abdulhadi, “Influence of a rotating frame on the peristaltic flow of a rabinowitsch fluid model in an inclined channel,” *J. Al-Qadisiyah Comput. Sci. Math.*, vol. 12, no. 1, p. Page-21, 2020.

[16] T. Hayat, M. Rafiq, and B. Ahmad, “Soret and Dufour effects on MHD peristaltic flow of Jeffrey fluid in a rotating system with porous medium,” *PLoS One*, vol. 11, no. 1, p. e0145525, 2016.

[17] A. Ahmad Dar and K. Elangovan, “Influence of an inclined magnetic field and rotation on the peristaltic flow of a micropolar fluid in an inclined channel,” *New J. Sci.*, vol. 2016, 2016.

[18] Z. Benharkat and M. N. Bouaziz, “MHD Rotating Fluid Past a Semi-Infinite Vertical Moving Plate: Coriolis Force and Wall Velocity Effects,” *J. Adv. Res. Fluid Mech. Therm. Sci.*, vol. 60, no. 1, pp. 38–51, 2019.

[19] A. A. Khan, H. Usman, K. Vafai, and R. Ellahi, “Study of peristaltic flow of magnetohydrodynamics Walter’s B fluid with slip and heat transfer,” *Sci. Iran.*, vol. 23, no. 6, pp. 2650–2662, 2016.

[20] Z. A. Jaafar, L. Z. Hummady, and M. H. Thawi, “Effects of Rotation and Inclined Magnetic Field on Walters’ B Fluid in a Porous Medium using perturbation method or technique.,” *Iraqi J. Sci.*, 2024.

[21] S. BARIŞ, “Steady flow of a Walter’s B’viscoelastic fluid between a porous elliptic plate and the ground,” *Turkish J. Eng. Environ. Sci.*, vol. 26, no. 5, pp. 403–418, 2002.