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Effect of Rotation on Peristaltic flow for Powell-Eyring in Asymmetric channel with porous medium.

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ABSTRACT

In this paper, we studied, peristaltic motion and rotation for Powell - Eyring fluid in an asymmetric channel with porous medium. The motion equations have been solved by the well-known analytical methods, which is the perturbation technique, under the assumption of long wave length and low Reynolds number a proximation.

The study established that several dimensionless characteristics regulate mobility. Each of these dimensionless elements' impact on pressure and velocity, as well as the key aspects of pumping characteristics and the contour plot for the stream lines and trapping, were examined.

MSC..

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1. Introduction

The area of physics known as fluid mechanics is focused on the forces acting on and within fluids (liquids, gases, and plasmas). It has uses in many fields, including biology, geophysics, oceanography, meteorology, astrophysics, and mechanical, aeronautical, civil, chemical, and biomedical engineering. Peristaltic motion is a series of contractions and diastoles that push fluid along the path, making it easier to move. Peristalsis is a natural property of smooth muscles and tubes that carry fluid through vessels as a result of motor activity in numerous biological systems. The passage of urine from the kidney to the bladder, the movement of food through the gastrointestinal tract, and the migration of eggs through the fallopian tube are all examples of this movement [1]. Engineers who measure viscosity and then use the generalized Newtonian fluid model to describe flow are particularly interested. A few important studies for the peristaltic flow of Powell–Eyring fluid have indeed been discovered through studies, the suggested that nanoparticles be introduced to fluids to increase heat transfer abilities of these base liquids [2]. The influence of heat and mass transfer on the peristaltic transport of viscoelastic fluid in presence of a magnetic field through a symmetric channel with a porous medium has been investigated

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[3]. Hatem has studied the analysis of the effect of rotation on the analysis of heat transfer by mixed convection for the peristaltic transport of a viscous liquid in an asymmetric channel [4], and also analyzed the effect of rotation and magnetic field on the analysis of heat transfer by mixed convection of a viscous liquid through a porous medium in an asymmetric [5]. The influence of heat and mass transfer on the peristaltic transport of viscoelastic fluid in presence of a magnetic field through a symmetric channel with porous medium has been investigated [6]. The influence of heat and mass transfer on peristaltic flow for MHD Powell-Eyring fluid with slip condition was discussed [7]. The influence of slip conditions on Eyring-Powell fluid peristaltic flow was investigated [8]. Non-Newtonian fluids are governed by the Powell-Eyring fluid model. The research is carried out under the assumption of a long wavelength and a low Reynold number. The wave frame was used to develop the flow's governing equation. Closed expressions for stream function, Rotation, velocity axial, and pressure gradient were determined, as well as numerical integration of pressure rise per unit wave using series approximation. Finally, a graphical analysis was performed to determine. This study was done by plotting graphs by using "MATHEMATICA".

2. Mathematic Formulation

Consider the flow of an incompressible Powell-Eyring fluid in a two-dimensional asymmetric channel of width (d + d') The flow is caused by an infinite sinusoidal wave line moving forward and with constant velocity (c) along the channel's walls. An asymmetric channel is formed by varying wave amplitudes, phase angles, and channel widths.

The geometries of the walls are modeled as

$$\overline{h_1}(\bar{x},\bar{t}) = d - a_1 \sin[\frac{2\pi}{\lambda}(\bar{x} - c\bar{t})] \text{ upper wall,} \quad (1)$$

$$\overline{h_2}(\bar{x},\bar{t}) = -d' - a_2 \sin[\frac{2\pi}{\lambda}(\bar{x} - c\bar{t}) + \emptyset] \text{ lower wall.} \quad (2)$$

where (a_1) and (a_2) denote the amplitudes of the wave, (d) and (d') represents the width of the channel, (λ) designates the wavelength, ($\bar{X}$) represents the direction of the propagation of wave and ($\bar{t}$) stands for the time. The phase difference ($\emptyset$) fluctuates within the range ($0 \le \emptyset \le \pi$) in which ($\emptyset = 0$) corresponds to asymmetric channel with waves out of phase and ($\emptyset = \pi$) stands for the waves in phase. Further (a_1), (a_2), (d), (d'), and ($\emptyset$) satisfy the condition:

$$a_1^2 + a_2^2 + 2a_1a_2\cos(\emptyset) \le (d + d')^2.$$

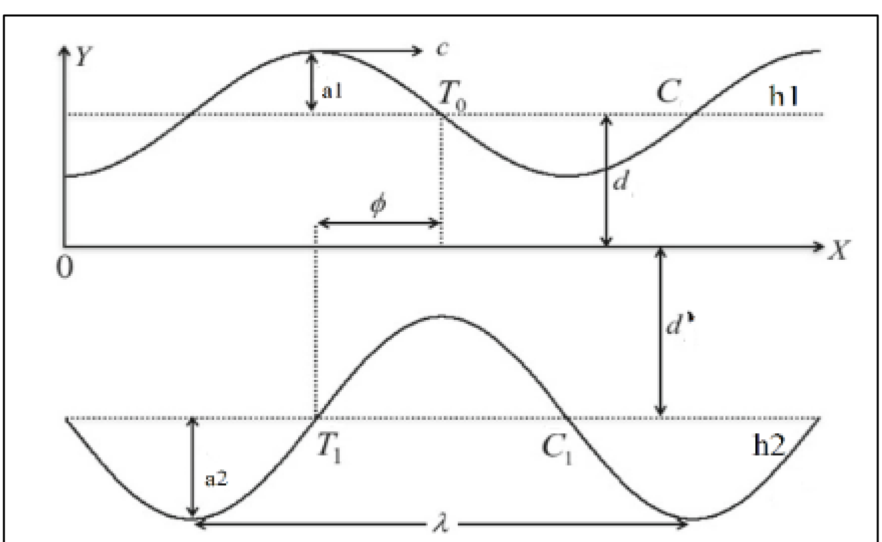


Figure 1. Cartesian Dimensional Asymmetric Channels Coordinates.

It is further assumed that there is no motion of walls in the longitudinal direction. This assumption restricts the deformation of the walls, it does not imply that the channel is rigid along the longitudinal motions.

3. Basic Equations

The fluid is obeying the Powell-Eyring model and the Cauchy stress tensor $(\bar{\tau})$ of it is given as follows.

$$\bar{\tau} = -\mathrm{P}I + \bar{S}, \quad (3)$$

$$\bar{S} = \left[\mu + \frac{1}{\beta\dot{\gamma}}\sinh^{-1}\left(\frac{\dot{\gamma}}{c_1}\right)\right]A_{11}, \quad (4)$$

$$\dot{\gamma} = \sqrt{\frac{1}{2}\mathrm{tras}(A_{11})^2}\ , \quad (5)$$

The terms $\sinh^{-1}$ is approximated as

$$\sinh^{-1}\left(\frac{\dot{\gamma}}{c_1}\right) = \frac{\dot{\gamma}}{c_1} - \frac{\dot{\gamma}^3}{6\,c_1{}^3}, \left|\frac{\dot{\gamma}^5}{c_1{}^5}\right| \ll 1\ . \quad (6)$$

Where $(\bar{S})$ express the extra stress tensor, (I) the identity tensor, $\bar{\nabla}=(\partial\bar{X}, \partial\bar{Y}, 0)$ the gradient vector, (β, c_1) the martial parameters of Powell-Eyring fluid, $(\bar{P})$ the pressure of the fluid and (μ) the dynamic viscosity.

$$\bar{s}_{\bar{x}\bar{x}} = 2\left(\mu + \frac{1}{\beta\,c_1}\right)\bar{u}_{\bar{x}} - \frac{1}{3\,\beta\,c_1{}^3}\left[2\bar{u}_{\bar{x}}{}^2 + \left(\bar{v}_{\bar{x}} + \bar{u}_{\bar{y}}\right)^2 + 2\bar{v}^2{}_{\bar{y}}\right]\bar{u}_{\bar{x}}\ , \quad (7)$$

$$\bar{s}_{\bar{x}\bar{y}} = \bar{s}_{\bar{y}\bar{x}} = \left(\mu + \frac{1}{\beta\,c_1}\right)(\bar{v}_{\bar{x}} + \bar{u}_{\bar{y}}) - \frac{1}{6\,\beta\,c_1{}^3}\left[2\bar{u}_{\bar{x}}{}^2 + \left(\bar{v}_{\bar{x}} + \bar{u}_{\bar{y}}\right)^2 + 2\bar{v}^2{}_{\bar{y}}\right](\bar{v}_{\bar{x}} + \bar{u}_{\bar{y}}), \quad (8)$$

$$\bar{s}_{\bar{y}\bar{y}} = 2\left(\mu + \frac{1}{\beta\,c_1}\right)\bar{v}_{\bar{y}} - \frac{1}{3\,\beta\,c_1{}^3}\left[2\bar{u}_{\bar{x}}{}^2 + \left(\bar{v}_{\bar{x}} + \bar{u}_{\bar{y}}\right)^2 + 2\bar{v}^2{}_{\bar{y}}\right]\bar{v}_{\bar{y}}\ . \quad (9)$$

4. The Governing Equation

The continuity equation may be used to illustrate the fundamental equations of motion in a peristaltic transport of Powel-Eyring fluid in experimental frame $(\bar{x}, \bar{y})$:

$$\frac{\partial\,\bar{u}}{\partial\bar{x}} + \frac{\partial\,\bar{v}}{\partial\bar{y}} = 0 \quad (10)$$

The $\bar{x}$ – part of the moment equation is:

$$\rho\left(\frac{\partial}{\partial\bar{t}} + \bar{u}\frac{\partial}{\partial\bar{x}} + \bar{v}\frac{\partial}{\partial\bar{y}}\right)\bar{u} - \rho\Omega\left(\Omega\bar{u} + 2\frac{\partial\,\bar{v}}{\partial\bar{t}}\right) = -\frac{\partial\bar{p}}{\partial\bar{x}} + \frac{\partial}{\partial\bar{x}}\bar{s}_{\bar{x}\bar{x}} + \frac{\partial}{\partial\bar{y}}\bar{s}_{\bar{x}\bar{y}} - \frac{\mu}{\bar{k}}\bar{u} \quad (11)$$

The $\bar{y}$ – part of the moment equation is:

$$\rho\left(\frac{\partial}{\partial\bar{t}} + \bar{u}\frac{\partial}{\partial\bar{x}} + \bar{v}\frac{\partial}{\partial\bar{y}}\right)\bar{v} - \rho\Omega\left(\Omega\bar{v} - 2\frac{\partial\,\bar{u}}{\partial\bar{t}}\right) = -\frac{\partial\bar{p}}{\partial\bar{y}} + \frac{\partial}{\partial\bar{x}}\bar{s}_{\bar{x}\bar{y}} + \frac{\partial}{\partial\bar{y}}\bar{s}_{\bar{y}\bar{y}} - \frac{\mu}{\bar{k}}\bar{v} \quad (12)$$

Where the (ρ) , $(\bar{p})$, (μ), $(\bar{k})$, (B_0),(Ω) is constant density, pressure, dynamic viscosity, permeability parameter, rotation. The relationship between coordinates, velocity and pressure in laboratory frame (X, Y) and wave frame $(\bar{x}, \bar{y})$ is provided by the following transformations.

The flow in the laboratory frame is erratic $(\bar{x}, \bar{y})$. Therefore, with a coordinate system traveling at the speed of a wave (c) in wave frame $(\bar{X}, \bar{Y})$, the motion is steady. The following expressions

$$\bar{x} = \bar{X} - c\bar{t}\,, \bar{y} = \bar{Y}\,, \bar{u}(\bar{X},\bar{Y}) = \bar{U}(\bar{x},\bar{y}) - c\,, \bar{v}(\bar{X},\bar{Y}) = \bar{V}(\bar{x},\bar{y}), \bar{P}(\bar{X}) = \bar{P}(\bar{x},\bar{t}) \tag{13}$$

where $\bar{u}, \bar{v}$ and $\bar{p}$ represent the velocity components and pressure in the wave frame.

Set up the following non-dimensional quantities to perform the non-dimensional analysis:

$$x = \frac{1}{\lambda}\bar{x}\; y = \frac{1}{d}\bar{y}\,, u = \frac{1}{c}\bar{u}\,, v = \frac{1}{\delta\, c}\bar{v}\,, t = \frac{c}{\lambda}\bar{t}\,, \delta = \frac{d}{\lambda}\,, Re = \frac{\rho\, c\, d}{\mu}, Da = \frac{\bar{k}}{d^2}\,, s_{xx} = \frac{\lambda}{\mu\, c}\bar{s}_{\bar{x}\bar{x}}, s_{xy} = \frac{d}{\mu\, c}\bar{s}_{\bar{x}\bar{y}}\,,$$

$$s_{yy} = \frac{d}{\mu\, c}\bar{s}_{\bar{y}\bar{y}}\,, M = \sqrt{\frac{\sigma B_0^2 d^2}{\mu}}, h_1 = \frac{1}{d}\overline{h_1}\,,\; h_2 = \frac{1}{d}\overline{h_2}\,,\; \beta = M^2 + \frac{1}{Da}\,, R_n = \frac{\tau_0 d}{\mu c}\; p = \frac{d^2}{\lambda\mu\, c}\bar{p}\,, \tag{14}$$

where (δ) wave number, (Re) Reynold number, (M) Magnetic field, ($\emptyset$) phase difference, (Da) Darcy number.

Then, in view of equation (14), Equations (1), (2), and (7) to (12) take the form:

The equation (1) becomes:

$$h_1(x,t) = 1 - a\sin(2\pi x\,),\; a = \frac{a_1}{d}, \tag{15}$$

The equation (2) becomes:

$$h_2(x,t) = -d^* - b\sin(\,2\pi x + \emptyset)\,, d^* = \frac{d'}{d}, b = \frac{a_2}{d}\,. \tag{16}$$

The equation (7) becomes:

$$s_{xx} = 2(w+1)\frac{\partial u}{\partial x} - 2A\left[2\delta^2\left(\frac{\partial u}{\partial x}\right)^2 + \left(\delta^2\,\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2 + 2\delta^2\left(\frac{\partial v}{\partial y}\right)^2\right]\frac{\partial u}{\partial x}\,. \tag{17}$$

The equation (8) becomes:

$$s_{xy} = (w+1)\left(\delta^2\,\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right) - A\left[2\delta^2\left(\frac{\partial u}{\partial x}\right)^2 + \left(\delta^2\,\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2 + 2\delta^2\left(\frac{\partial v}{\partial y}\right)^2\right]\left(\delta^2\,\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right). \tag{18}$$

The equation (9) becomes:

$$s_{yy} = 2(w+1)\,\delta\frac{\partial v}{\partial y} - 2A\delta\left[2\delta^2\left(\frac{\partial u}{\partial x}\right)^2 + \left(\delta^2\,\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2 + 2\delta^2\left(\frac{\partial v}{\partial y}\right)^2\right]\frac{\partial v}{\partial y}\,. \tag{19}$$

The equation (10) becomes:

$$\frac{\partial cu}{\partial \lambda x} + \frac{\partial c\delta v}{\partial dy} = 0\,,$$

Multiply by $(\frac{d}{c})$, we get:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0\,. \tag{20}$$

The equation (11) becomes

$$Re\,\delta\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) - \frac{\rho d^2}{\mu}\Omega^2 u - (2\Omega\delta^2 Re)\left(\frac{\partial v}{\partial t}\right) = -\frac{\partial p}{\partial x} + \delta^2\frac{\partial}{\partial x}s_{xx} + \frac{\partial}{\partial y}s_{xy} - \frac{1}{Da}u \tag{21}$$

And then equation (12) become

$$Re\,\delta^3\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) - \frac{\rho d^2}{\mu}\delta^2\Omega^2 v + (2\Omega\delta^2 Re)\left(\frac{\partial u}{\partial t}\right) = -\frac{\partial p}{\partial y} + \delta^2\frac{\partial}{\partial x}s_{xy} + \delta\frac{\partial}{\partial y}s_{yy} - \delta^2\frac{1}{Da}v\,. \tag{22}$$

The relations establish a connection between the velocity components and stream function (ψ):

$$u = \partial\psi/\partial y\;\;,\qquad v = -\,\partial\psi/\partial x \tag{23}$$

Substituted equation (23) in equations (17), (18), (19), (20), (21), (22) respectively

$$s_{xx} = 2(w+1)\frac{\partial^2\psi}{\partial x\,\partial y} - 2A\left[2\delta^2\left(\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2 + \left(-\delta^2\,\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}\right)^2 + 2\delta^2\left(-\,\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2\right]\frac{\partial^2\psi}{\partial x\,\partial y} \tag{24}$$

$$s_{xy} = (w+1)\left(-\delta^2\,\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}\right) - A\left[2\delta^2\left(\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2 + \left(-\delta^2\,\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}\right)^2 + 2\delta^2\left(-\,\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2\right]\left(-\delta^2\,\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}\right)\,, \tag{25}$$

$$s_{yy} = -2(w+1)\delta\frac{\partial^2\psi}{\partial x\,\partial y} - 2A\delta\left[2\delta^2\left(\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2 + \left(-\delta^2\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}\right)^2 + 2\delta^2\left(-\frac{\partial^2\psi}{\partial x\,\partial y}\right)^2\right]\left(-\frac{\partial^2\psi}{\partial x\,\partial y}\right) \quad (26)$$

$$\frac{\partial^2\psi}{\partial x\,\partial y} - \frac{\partial^2\psi}{\partial x\,\partial y} = 0, \quad (27)$$

$$\mathrm{Re}\,\delta\left(\frac{\partial^3\psi}{\partial x\,\partial y^2} - \frac{\partial^3\psi}{\partial x\,\partial y^2}\right) - \frac{\rho d^2}{\mu}\Omega^2\frac{\partial\psi}{\partial y} - (2\Omega\delta^2 Re)\left(\frac{\partial^2\psi}{\partial t\partial x}\right) = -\frac{\partial p}{\partial x} + \delta^2\frac{\partial}{\partial x}s_{xx} + \frac{\partial}{\partial y}s_{xy} - \frac{1}{Da}\frac{\partial\psi}{\partial y} \quad (28)$$

$$\mathrm{Re}\,\delta^3\left(\frac{\partial^3\psi}{\partial x^2\,\partial y} - \frac{\partial^3\psi}{\partial x^2\,\partial y}\right) - \frac{\rho d^2}{\mu}\delta^2\Omega^2\frac{\partial\psi}{\partial x} + (2\Omega\delta^2 Re)\left(\frac{\partial^2\psi}{\partial t\partial y}\right) = -\frac{\partial p}{\partial y} + \delta^2\frac{\partial}{\partial x}s_{xy} + \delta\frac{\partial}{\partial y}s_{yy} - \delta^2\frac{1}{Da}\frac{\partial\psi}{\partial x} \quad (29)$$

The dimensionless boundary conditions in the wave frame are [9]:

$$\psi = \frac{F}{2}, \frac{\partial\psi}{\partial y} = -1 \text{ at } y = h_1, \quad (30)$$

$$\psi = \frac{-F}{2}, \frac{\partial\psi}{\partial y} = -1 \text{ at } y = h_2. \quad (31)$$

5. solution of the Problem

It is impossible to provide a precise answer for each of the random parameters involved. We take perturbation strategy to get the answer. We go beyond treating the disorder

$$\psi = \psi_0 + A\,\psi_1 + O(A^2),$$

$$F = F_0 + AF_1 + O(A^2), \quad (32)$$

Substitute the terms (32) into equations (23)-(29), and the equations for the boundary conditions (31) ($\delta \ll 1$), We can create the following system of comparable powers (A) by equating the coefficients of the higher order components it entails because the power of (δ) is lower and inconsequential.

From equation (25) and equation (28) we get:

$$\frac{dp}{dx} = \xi\,\psi_y + \psi_{yyy} - \eta A\frac{\partial}{\partial y}(\psi_{yy})^3 - \beta\psi_y, \quad (33)$$

Form equation (2-43) we get:

$$-\frac{\partial p}{\partial y} = 0 \quad (34)$$

$$0 = \xi\,\psi_{yy} + \psi_{yyyy} - \eta\,A\frac{\partial^2}{\partial y^2}(\psi_{yy})^3 - \beta\psi_{yy}. \quad (35)$$

$$\xi = \frac{\frac{(\Omega^2 d^2\rho)}{\mu}}{w+1}, \quad (36)$$

$$\beta = \frac{\frac{1}{Da}}{w+1} \quad (37)$$

$$\eta = \frac{1}{w+1}, \quad (38)$$

$$\xi\,\psi_{0yy} + A\,\xi\,\psi_{1_{yy}} + \psi_{0yyyy} + A\psi_{1_{yyyy}} - \eta A \frac{\partial^2}{\partial y^2}\left(\psi_{0_{yy}}\right)^3 - \beta\,\psi_{0yy} - A\,\beta\,\psi_{1_{yy}} = 0 \tag{39}$$

5.1. Zero Order System

When the terms of order (A) are negligible in the zeroth order system, we get:

$$\xi\,\psi_{0yy} + \psi_{0yyyy} - \beta\,\psi_{0yy} = 0, \tag{40}$$

Such that

$\psi_0 = \frac{F_0}{2}, \frac{\partial\psi_0}{\partial y} = -1$ at y= h_1 and

$$\psi_0 = -\frac{F_0}{2}, \frac{\partial\psi_0}{\partial y} = -1 \text{ at } y = h_2. \tag{41}$$

5.2. First order system

$$\xi\,\psi_{1_{yy}} + \psi_{1_{yyyy}} - \eta \frac{\partial^2}{\partial y^2}\left(\psi_{0_{yy}}\right)^3 - \beta\,\psi_{1_{yy}} = 0, \tag{42}$$

$$\xi\,\psi_{1_{yy}} + \psi_{1_{yyyy}} - \beta\,\psi_{1_{yy}} = \eta \frac{\partial^2}{\partial y^2}\left(\psi_{0_{yy}}\right)^3, \tag{43}$$

$\psi_1 = \frac{F_1}{2}, \frac{\partial\psi_1}{\partial y} = -1$ at y= h_1 and

$$\psi_1 = -\frac{F_1}{2}, \frac{\partial\psi_1}{\partial y} = -1 \text{ at } y = h_2. \tag{44}$$

And get the final equation for stream function by solving the associated zeroth and first order systems:

$$\psi = \psi_0 + A\,\psi_1, \tag{45}$$

6. Results and Discussion

To investigate the impact of physical factors like Effect of, Darcy number (Da), Reynolds number (Re), material fluid parameters (A, w), Rotation (Ω), Porous medium parameter (k), Density (ρ), Viscosity (μ), pressure rise (Δp), the plotted axial velocity (u), phase difference (∅) and stream function (ψ) in figures. 2-10 are exemplified by software "MATHEMATICA".

6.1. Velocity Distribution (u)

Figures 2 demonstrate how the axial velocity (u) value can vary with respect to y for various rotational values (Ω), Darcy number (Da), Viscosity (μ), material fluid parameter (w,A), density (ρ) and amplitude ratio (∅). These figures (2) show that the maximum velocity is consistently found close to the channel's center and that All instances of the velocity profiles are parabolic. The figures show that the axial velocity decreases at the two walls of the channel and increases at the center of the channel as (Ω), (Da), (A), (ρ), (∅) and (d*) increase.

We notice that when (w) increases, the axial velocity decreases along the channel. When the viscosity (μ) increases, we notice that the axial speed is constant.

6.2. pressure gradient

Graphical representation of the impact of relevant parameters on the pressure gradient (dp/dx) is possible figures 3. We notice in the figures that when the values of (Da), (Ω), (ρ) and (w) increase, they decrease at the beginning of the left wall and then begin to increase in the middle of the channel as well as at the right wall of the channel. In the two figures, when the value of (A) increases and (d*) we notice that the pressure gradient increases along the channel. When the value of (∅) increases, we notice different disturbances in the rise and fall of pressure.

6.3. Pressure Rise (∆p)

Figures 4 display the various pressure increases in the wave outline's capability of volumetric stream rate for various Darcy number (Da), Rotation (Ω), material fluid parameter (w, A), density (ρ) and amplitude ratio (∅). The relationship between a dimensionless mean flow rate (Q1) and a non-dimensional average pressure rises per wavelength will be illustrated in this paragraph along with variations in the relevant parameters in (∆p). Figures shows the effect of increasing the parameter (Da) and (A) on (ΔP) reveals that pressure rice per wave length ΔP increase in magnitude in all regions.). Figure shows the effect of increasing the parameter (Ω), (β_1) and (∅) on (ΔP) reveals that pressure rice per wave length ΔP increase in magnitude in all regions. Figures (Ω)and (ρ), the pumping rate increases in a retrograde region where ($\Delta p > 0$, $Q1 > 0$) and lowers in a cop umping zone where ($\Delta p < 0$, $Q1 < 0$), according to the graph. Figure shows the pressure rice per wave length ΔP decreases in magnitude for fixed values of the (w), (∅) and (d).

6.4. Trapping phenomena

An interesting component happens in peristaltic flows closed movement strains lure bolus, or the extent of fluid called bolus, in the channel tube close to the partitions, and this trapping bolus advances along the path of the wave. In figures 5 –10 Plots of the stream lines are shown at different values of (Ω), (Da), (w), (A) and (d*). Figures it shows a shrinking of the trapped bolus when the (Ω), (Da), (d*) and (A) is increased. Figures the exhibits that the trapping exists in the focus of the channel, an increase in (w) and (∅) increases the size of bolus.

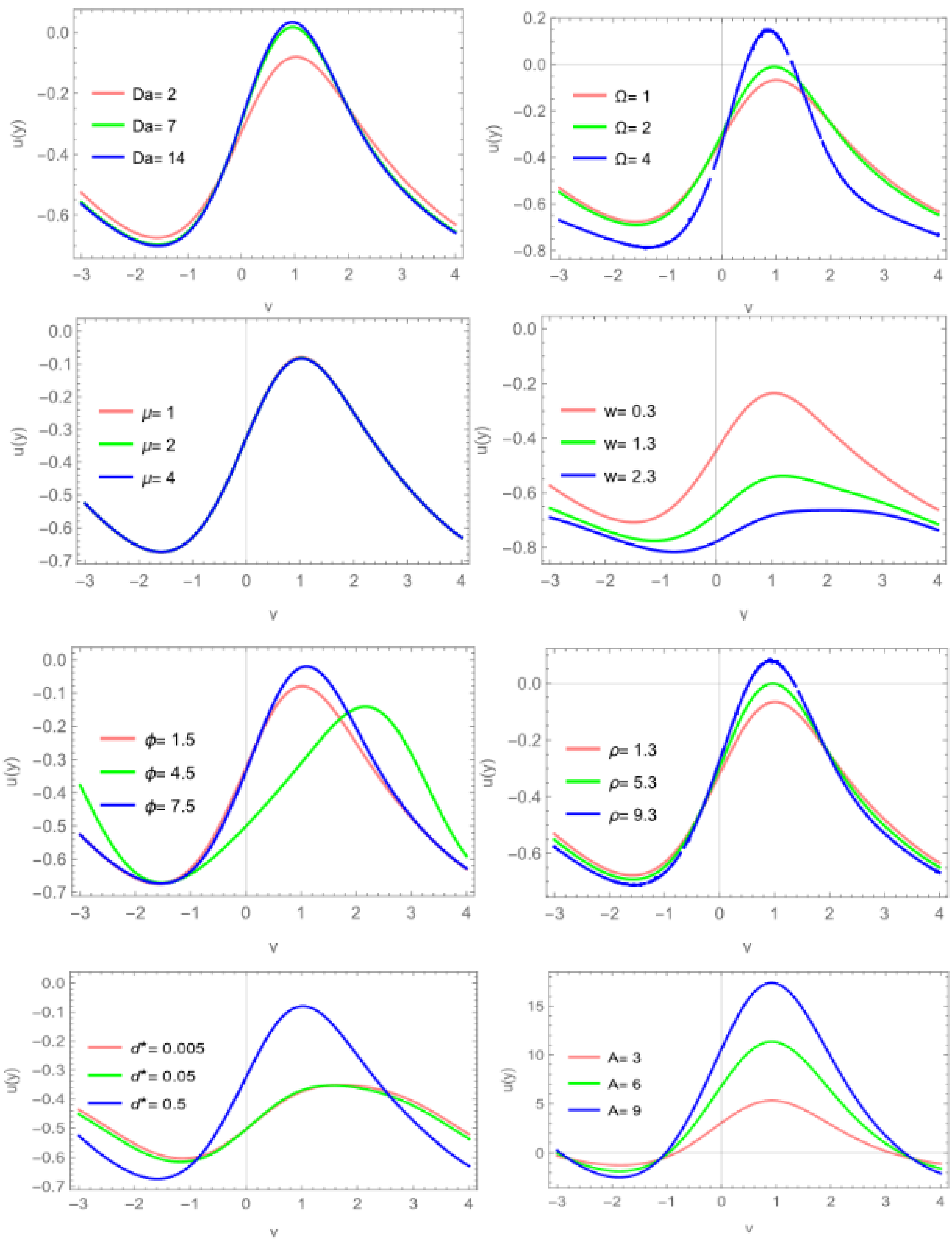


Figure 2. Variation of Ω, Da, A, w, ∅, ρ, d^*, and μ on the axial velocity (u) with respect to y.

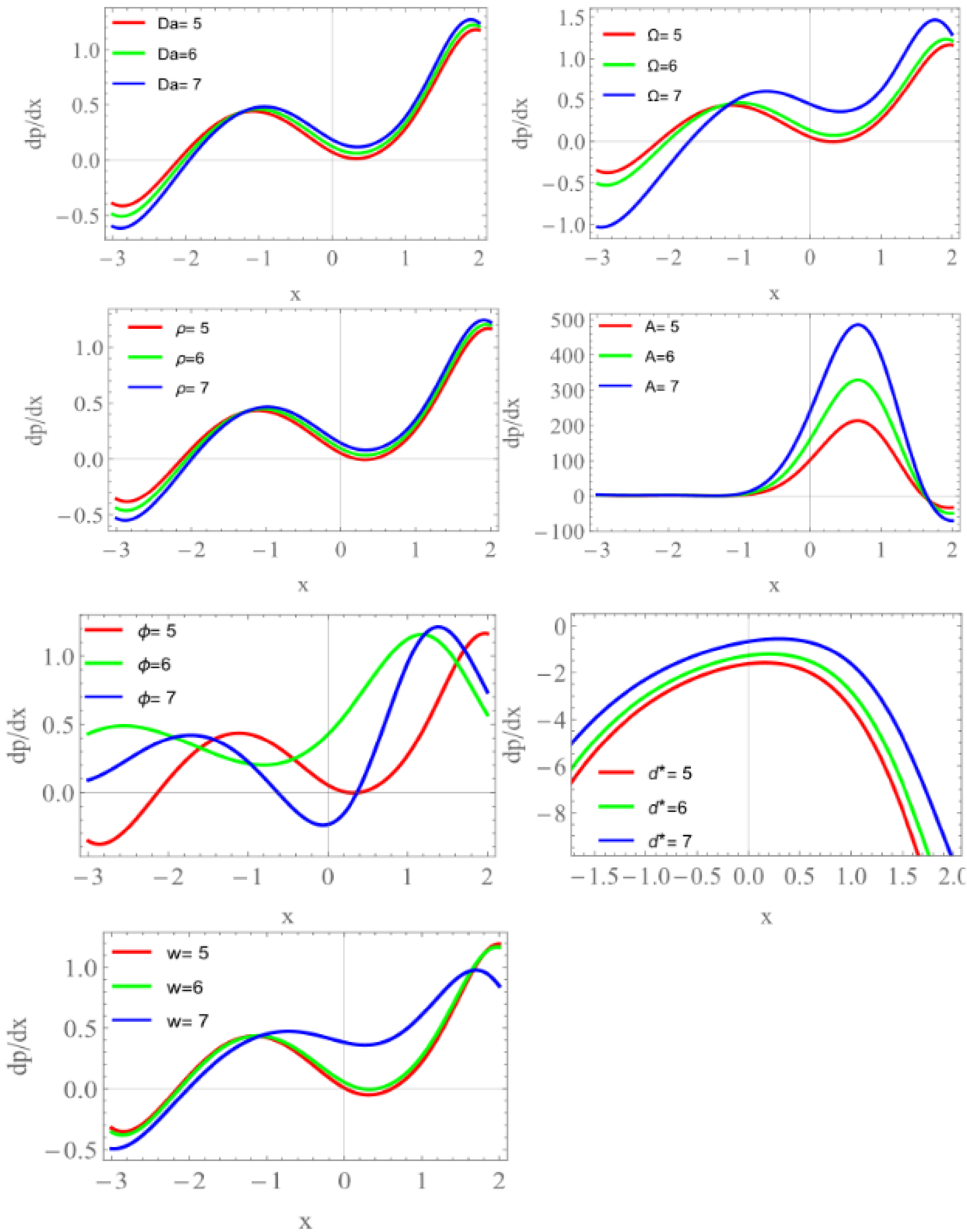


Figure 3. Variation of pressure gradient whit different parameter Ω, Da, A, w, ∅, ρ, d^*

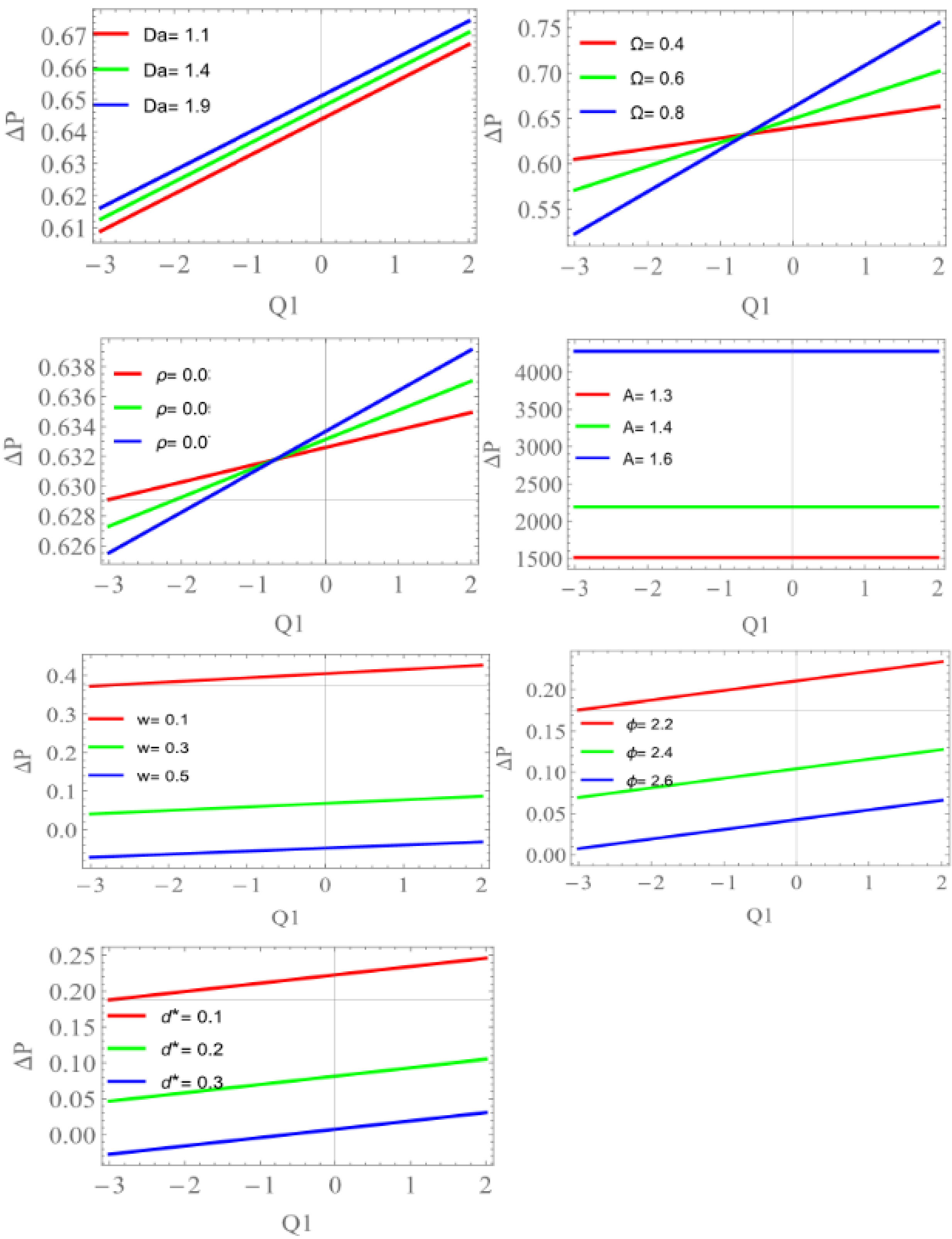
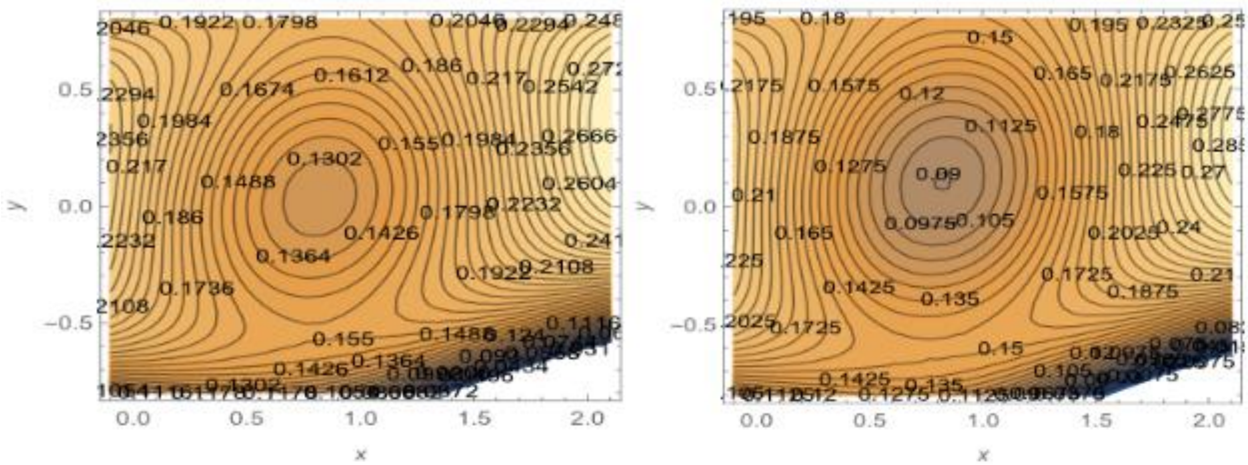


Figure 4. Variation of Ω, Da, A, w, ∅, ρ, d^* on the pressure rise per wavelength (Δp) against the volume flow rate $Q1$



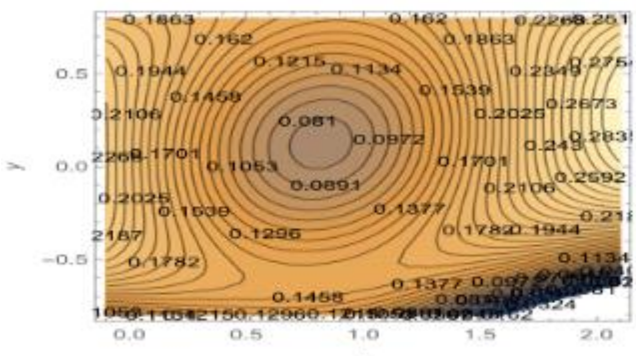
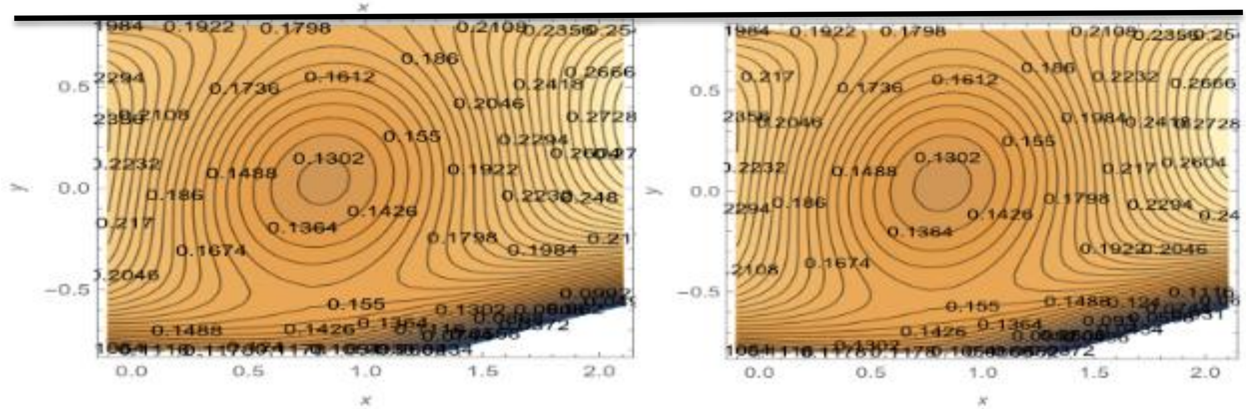


Figure 5. stream function in the wave frame of (Da) such that in (a) Da =2, (b) Da =4, (c) Da =6, in Ω= 0.5, A= 0.4, μ = 0.6, ρ =0.4, Ø = 0.4, a = 0.1, b = 0.3, d* =0.5, w = 0.2.



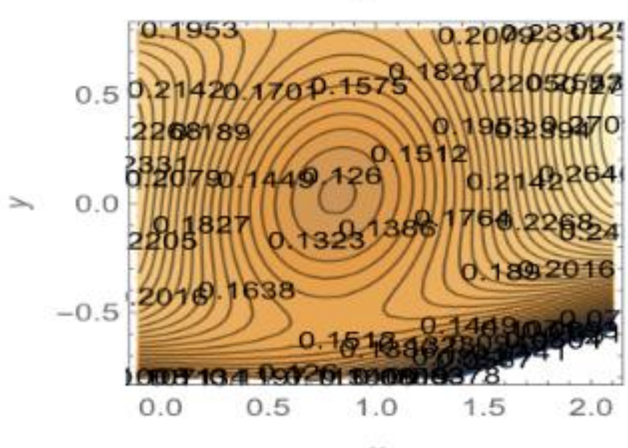
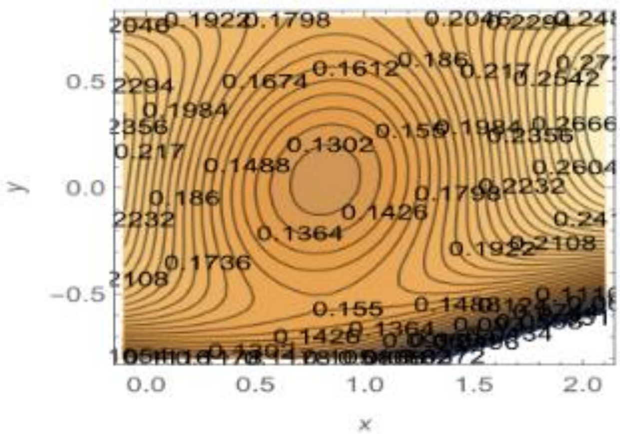
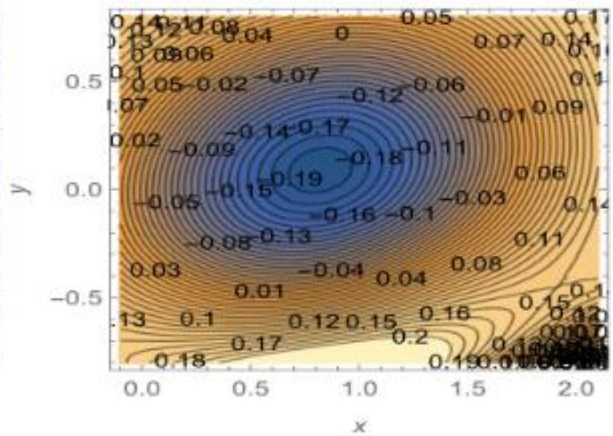


Figure 6. stream function in the wave frame of (Ω) such that in (a) Ω =0.1, (b) Ω =0.3, (c) Ω =0.6, in Da= 2, A= 0.4, μ = 0.6, ρ =0.4, Ø = 0.4, a = 0.1, b = 0.3, d* =0.5, w = 0.2.





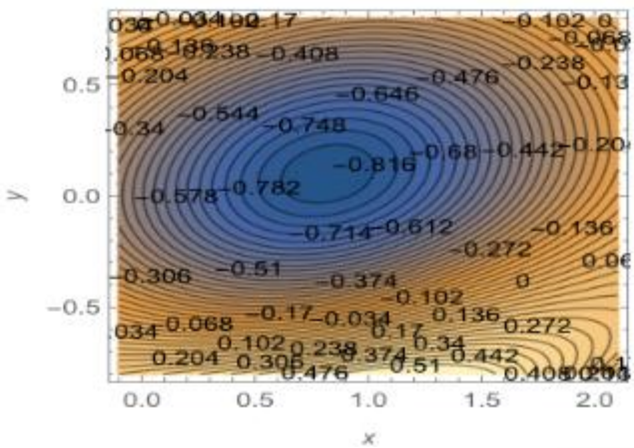
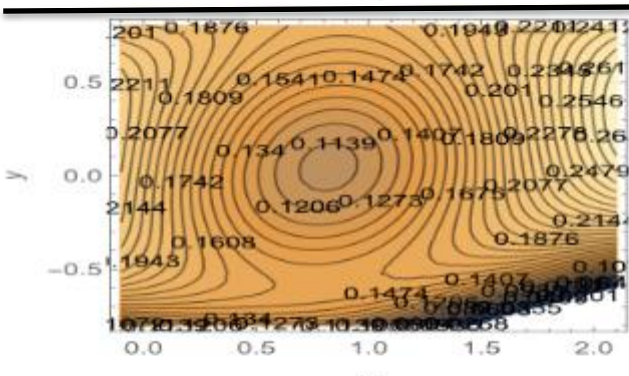
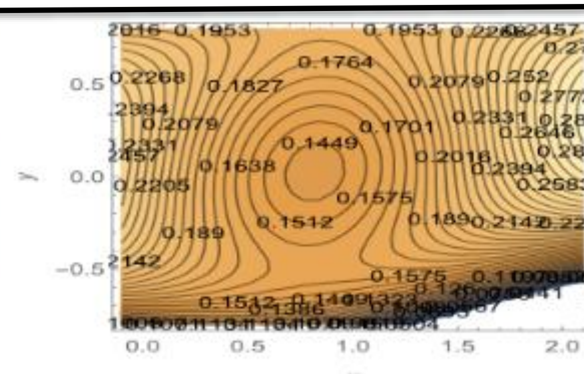


Figure 7. stream function in the wave frame of (A) such that in (a) A=0.3, (b) A =0.5, (c) A =0.9, in Da= 2, Ω = 0.5, μ = 0.6, ρ =0.4, Ø = 0.4, a = 0.1, b = 0.3, d* =0.5, w = 0.2.





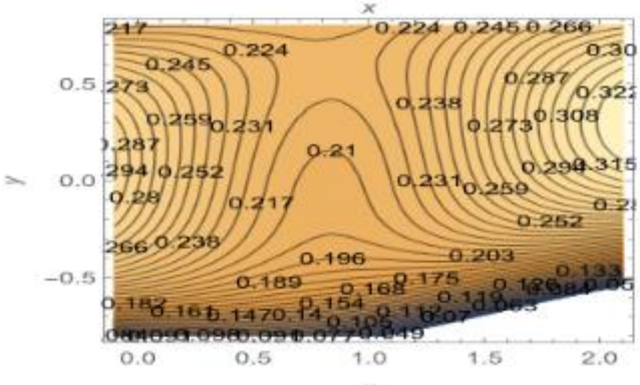
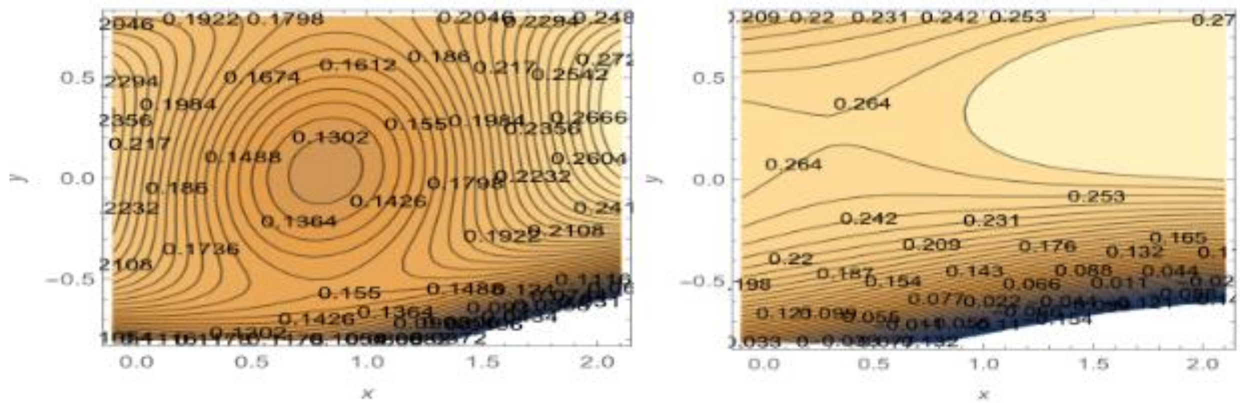


Figure 8. stream function in the wave frame of (w) such that in (a) w=0.003, (b) w =0.06, (c) w =0.2, in Da= 2, Ω = 0.5, μ = 0.6, ρ =0.4, Ø = 0.4, a = 0.1, b = 0.3, d* =0.5,A = 0.4.



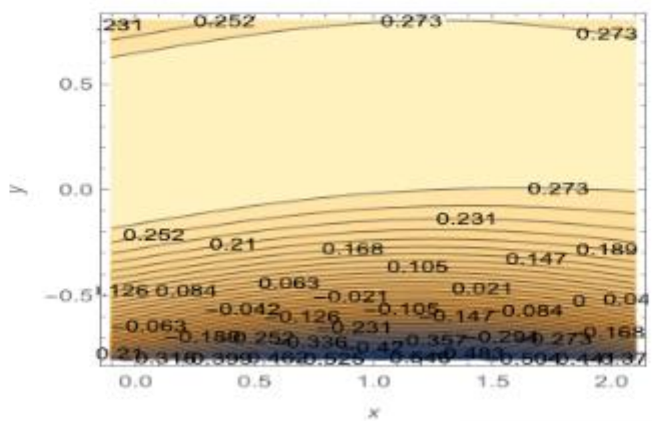
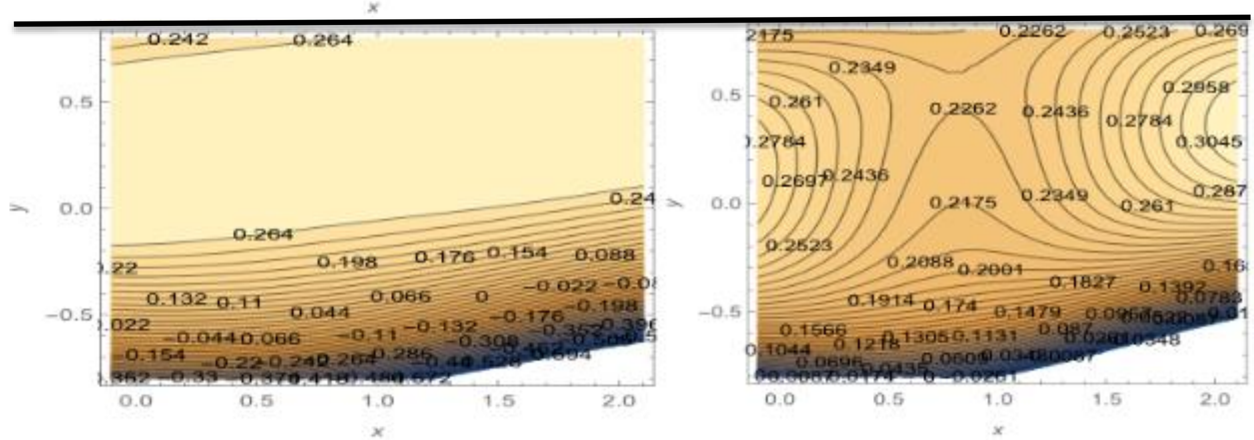


Figure 9 stream function in the wave frame of (Ø) such that in (a) Ø =1.5, (b) Ø =2.5, (c) Ø =3.5, in *Da*= 2, *Ω* = 0.5, μ = 0.6, *ρ* =0.4, A = 0.4, a = 0.1, b = 0.3, d* =0.5, *w* = 0.2.



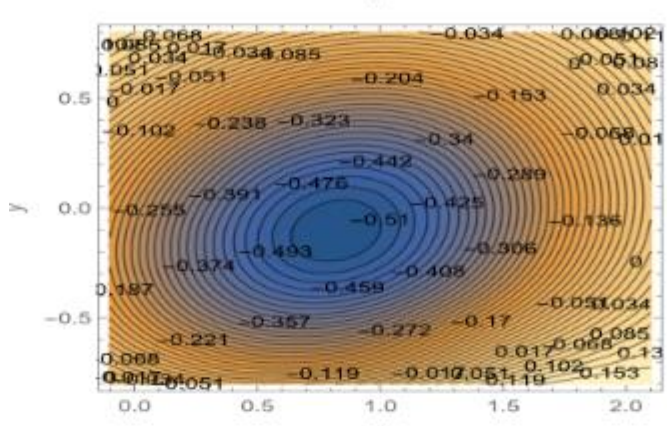


Figure 10. stream function in the wave frame of (d*) such that in (a) d*=1.5, (b) d*=2.5, (c) d* =3.5, in *Da*= 2, *Ω* = 0.5, μ = 0.6, *ρ* =0.4, A = 0.4, a = 0.1, b = 0.3, Ø =0.4, *w* = 0.2.

7. Conclusions

The peristaltic motion of Powell - Eyring fluid in an asymmetric channel with a porous material was examined in this study to determine the rotation on it. By choosing peristaltic waves with various ranges, phases, low Reynolds numbers, and wavelengths, the asymmetric duct is created. The expression for the axial velocity, pressure, flow function, and current density were also obtained using an application of the perturbation method. Graphs are used to illustrate the findings as follows:

1- Velocity is a decreasing function of the material parameter w whereas it is a increasing function of the Darcy number Da, rotation Ω and ∅.

2- The influence of relevant parameters on pumping rate varies depending on the pumping region

3- The pressure rise enhances above the critical value of flow rate with higher values of Darcy number and rotation.

4- For higher values of Ω, Da and A, the size of the trapped bolus decreases while it increases with increasing w and ∅.

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