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Numerical Treatment to Study the Effect of Wall Properties on the Peristaltic Motion ofHerschel-Bulkley Fluid Through a Vertical Porous Channel

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ABSTRACT

Numerical solutions of the system of non-linear differential equations which describe the peristaltic transport of non-Newtonian fluid through porous medium in a symmetric two-dimension vertical channel with heat and mass transfer are obtained. The fluid under consideration obeying the Herschel-Bulkley model and the wall properties are taken in consideration. The equations of momentum, energy and concentration are solved numerically using the finite difference method. The computations are carried out for wide range of the various physical parameters associated with the Herschel-Bulkley fluid.The effects of various parameters on the velocity, temperature and concentration are illustrated graphically.

1. INTRODUCTION

Peristaltic transport is a form of material transport induced by a progressive wave of area contraction or expansion along the length of a distensible tube, mixing and transporting the fluid in the direction of the wave propagation. This phenomenon is known as peristalsis. The mechanics of peristalsis has been examined by a number of investigators. Sankad and Radhakrishnamacharya [1] investigate the influence of wall properties on the peristaltic motion of aHerschel-Bulkley fluid in channel. Flow ofHerschel-Bulkley fluid in an inclined flexible channel lined with porous material under peristalsis was done by Sreenadh *et al*., [2]. The effect of heat transfer on peristaltic transport of a Newtonian fluid through a porous medium in an asymmetric vertical channel was studied by Vasudev [3]. Peristaltic flow of a Newtonian fluid through a porous medium in a vertical tube under the effect of magnetic field was studied by Vasudev *et al*., [4]. Eldabe *et al*., [5] discussed the thermal-diffusion and diffusion-thermo effects on mixed free-forced convection and mass transfer boundary layer flow for non-Newtonian fluid with temperature dependent viscosity. The flow separation through peristaltic motion for Power-law fluid in uniform tubestudied and reported by Abd El-Naby and Abd El Kareem [6]. Hayat and Javed [7] considered the exact solutions to peristaltic transport of Power-law fluid in asymmetric channel with compliant walls. Peristaltic flow of Williamson fluid in an asymmetric channel through porous medium analyzed by Kavitha *et al*., [8]. Hayat *et al*., [9] discussed the heat transfer analysis for peristaltic mechanism in variable viscosity fluid.Peristaltic pumping of Williamson fluid through a porous medium in a horizontal channel with heat transfer was investigated by Casudeu *et al*., [10].The peristaltic pumping of a non-Newtonian fluid analyzed by Medhavi [11].

The objective of the present paper is to investigate the effects ofthe wall properties on peristaltic transport of Herschel-Bulkley fluid through porous medium in a symmetric two-dimension vertical channel with heat and mass transfer. The equations of momentum, energy and concentration which govern the fluid field

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are solved numerically by using finite difference scheme. The effects of the fluid parameters on the velocity, temperature and concentration distributions have been studied with the help of graphs.

2. MATHEMATICAL ANALYSIS

Let us consider the flow of Herschel-Bulkley fluid through a porous medium in a symmetric twodimensional vertical channel with flexible walls on which are imposed traveling sinusoidal waves of long wave length. The coordinate system used is given in Fig. (1).

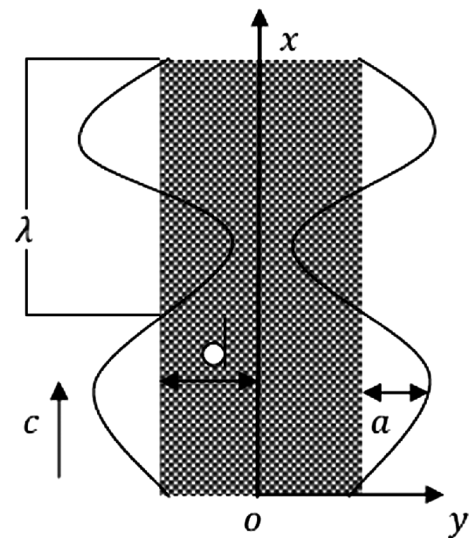

Figure 1: Geometry of Peristaltic Transport of Fluid in a Symmetric Porous Channel

The traveling waves are represented by:

$$\eta = d + a \sin\left(\frac{2\pi}{\lambda}(x - ct)\right). \tag{1}$$

Where d is the half width of the channel, a is the amplitude of the wave, λ is the wavelength, t is the time and c is the wave velocity.

The governing equations used in this problem can be written in the forms:

The continuity equation:

$$\nabla . \mathbf{V} = 0. \tag{2}$$

The momentum equation:

$$\rho\left(\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V}\cdot\nabla)\mathbf{V}\right) = -\nabla P + \nabla\cdot\tau - \frac{\mu}{k_0}(\mathbf{V} + c) + \rho g \alpha (T - T_0) + \rho g \alpha^* (\varphi - \varphi_0). \tag{3}$$

The temperature equation:

$$\rho c_p \left(\frac{\partial T}{\partial t} + (\mathbf{V}\cdot\nabla)T\right) = k\nabla^2 T + \frac{D_m k_T \rho}{C_s}\nabla^2\varphi + Q_0. \tag{4}$$

The concentration equation:

$$\left(\frac{\partial \varphi}{\partial t} + (\mathbf{V}\cdot\nabla)\varphi\right) = D_m \nabla^2\varphi + \frac{D_m k_T}{T_m}\nabla^2 T. \tag{5}$$

Where $\mathbf{V}(u, v)$, T and φ are the velocity vector, temperature and concentration, ρ, c_p, p, μ, g, α, α^*, k, k_0, k_T, T_m, C_s, Q_0 and D_m are the density of the fluid, specific heat, pressure,viscosity, acceleration due to gravity, coefficient of thermal expansion, coefficient of expansion with concentration, thermal conductivity, permeability of a porous medium, thermal diffusion ratio, mean fluid temperature, concentration susceptibility, constant heat addition/absorption and coefficient of mass diffusivity.

We choose a Herschel-Bulkley model [1] to describe the non-Newtonian fluid, which is in the usual notation:

$$\tau = \tau_0 + \mu \dot{\gamma}^n (\tau > \tau_0). \tag{6}$$

Where τ and $\dot{\gamma}$ are the stress and strain rate, τ_0 is the constant yield stress above which the substance starts to flow and n the flow behavior index of the fluid. The Herschel-Bulkley model reduces to the Power-low when $\tau_0 = 0$, to the Bingham plastic when $n = 1$, and to Newtonian's law for viscous fluids when both these conditions are satisfied.

The equation of motion of the flexible wall is given by:

$$L(\eta) = P - P_0. \tag{7}$$

Where L is an operator that is used to represnt the motion of the stretched membrance with damping forces such that:

$$L = -T_2 \frac{\partial^2}{\partial x^2} + M_1 \frac{\partial^2}{\partial t^2} + C_1 \frac{\partial}{\partial t}. \tag{8}$$

Where T_2 the tension in the membrane is, M_1 is the mass per unit area, C_1 is the coefficient of the damping force and P_0 is the pressure on the outside of the wall due to tension in the muscles.

If we assume that $P_0 = 0$, then equations (3-5) in two-dimensional form can be written as:

$$\rho\left[\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right] = -\frac{\partial P}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} - \frac{\mu}{k_0}(u+c) + \rho g\alpha(T - T_0) + \rho g\alpha^*(\varphi - \varphi_0), \tag{9}$$

$$\rho\left[\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right] = -\frac{\partial P}{\partial x} + \frac{\partial \tau_{yx}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} - \frac{\mu}{k_0} v, \tag{10}$$

$$\rho c_p\left[\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right] = k\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right] + \frac{D_m k_T \rho}{C_s}\left[\frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2}\right] + Q_0, \tag{11}$$

$$\left[\frac{\partial \varphi}{\partial t} + u\frac{\partial \varphi}{\partial x} + v\frac{\partial \varphi}{\partial y}\right] = D_m\left[\frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2}\right] + \frac{D_m k_T}{T_m}\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right]. \tag{12}$$

The appropriate boundary conditions are:

$$\left.\begin{aligned} &u = 0, \quad T = T_0 \quad \text{and} \quad \varphi = \varphi_0 \quad \text{at} \quad y = -\eta \\ &u = 0, \quad T = T_1 \quad \text{and} \quad \varphi = \varphi_1 \quad \text{at} \quad y = \eta \end{aligned}\right\} \tag{13}$$

Let us introduce the following dimensionless quantities as:

$$x^*=\frac{x}{\lambda},\quad y^*=\frac{y}{d},\quad \eta^*=\frac{\eta}{d},\quad t^*=\frac{tv}{\lambda d},\quad u^*=\frac{u}{c},\quad v^*=\frac{v}{c\delta},\quad \delta=\frac{d}{\lambda},\quad p^*=\frac{pd^2}{\mu\lambda c},$$
$$T^*=\frac{T-T_0}{T_1-T_0},\quad u^*=\frac{\varphi-\varphi_0}{\varphi_1-\varphi_0}. \tag{14}$$

After substituting from (14), Equations (9-12) can be written in dimensionless form after dropping the star mark as:

$$\mathrm{Re}\,\delta\left[\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right]=-\frac{\partial P}{\partial x}+nA_1\left[2\delta^{n+1}\left(\frac{\partial u}{\partial x}\right)^{n-1}\frac{\partial^2 u}{\partial x^2}+\left(\frac{1}{2}\left(\frac{\partial u}{\partial y}+\delta^2\frac{\partial v}{\partial x}\right)\right)^{n-1}\left(\frac{\partial^2 u}{\partial y^2}+\delta^2\frac{\partial^2 v}{\partial x\partial y}\right)\right]$$
$$-\frac{1}{D_a}(u+1)+G_{rT}T+G_{rm}\varphi \tag{15}$$

$$\mathrm{Re}\,\delta^3\left[\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right]=-\frac{\partial P}{\partial y}+\delta^2 nA_1\left[\left(\frac{1}{2}\left(\frac{\partial u}{\partial y}+\delta^2\frac{\partial v}{\partial x}\right)\right)^{n-1}\left(\frac{\partial^2 u}{\partial x\partial y}+\delta^2\frac{\partial^2 v}{\partial x^2}\right)+2\left(\frac{\partial v}{\partial y}\right)^{n-1}\frac{\partial^2 v}{\partial y^2}\right]$$
$$-\delta^2\frac{d^2}{k_0}v \tag{16}$$

$$\mathrm{Re}\,P_r\,\delta\left[\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right]=\left[\delta^2\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right]+D_f\,P_r\left[\delta^2\frac{\partial^2\varphi}{\partial x^2}+\frac{\partial^2\varphi}{\partial y^2}\right]+\beta \tag{17}$$

$$\delta\left[\frac{\partial\varphi}{\partial t}+u\frac{\partial\varphi}{\partial x}+v\frac{\partial\varphi}{\partial y}\right]=\frac{1}{S_c}\left[\delta^2\frac{\partial^2\varphi}{\partial x^2}+\frac{\partial^2\varphi}{\partial y^2}\right]+S_r\left[\delta^2\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right] \tag{18}$$

For long wavelength(i.e., $\delta \ll 1$) and low Reynolds number (i.e., $\mathrm{Re}\to 0$) the system of our equations can be reduced to:

$$nA_1\left(\frac{1}{2}\frac{\partial u}{\partial y}\right)^{n-1}\frac{\partial^2 u}{\partial y^2}-\frac{1}{D_a}(u+1)+G_{rT}T+G_{rm}\varphi=\frac{\partial p}{\partial x} \tag{19}$$

$$\frac{\partial P}{\partial y}=0 \tag{20}$$

$$\frac{\partial^2 T}{\partial y^2}+D_f\,P_r\frac{\partial^2\varphi}{\partial y^2}+\beta=0 \tag{21}$$

$$\frac{1}{S_c}\frac{\partial^2\varphi}{\partial y^2}+S_r\frac{\partial^2 T}{\partial y^2}=0 \tag{22}$$

From equation (20), it is clear that p is independent of y. Therefore equation (19) can be written as:

$$nA_1\left(\frac{1}{2}\frac{\partial u}{\partial y}\right)^{n-1}\frac{\partial^2 u}{\partial y^2}-\frac{1}{D_a}(u+1)+G_{rT}T+G_{rm}\varphi=\frac{\partial p}{\partial x}. \tag{23}$$

By using equations (7) and (8) with the help of the wall equation (1) we can write:

$$\frac{\partial p}{\partial x}=-\epsilon[(2\pi)^3\cos 2\pi(x-t)(E_1+E_2)-(2\pi)^2E_3\sin 2\pi(x-t)]. \tag{24}$$

Where $E_1=-\frac{T_2 d^3}{\rho v^2\lambda^3}$ is the membrane tension parameter, $E_2=\frac{M_1 d}{\rho\lambda^3}$ is the mass charactrizing parameter, $E_3=\frac{C_1 d^2}{\rho v\lambda^2}$ is the damping parameter, $\epsilon=\frac{a}{d}$ is the amplitude ratio, $A_1=\frac{c^{n-1}}{1d^{n-1}}$ is the non-Newtonian parameter, $D_a=\frac{k_0}{d^2}$ is the Darcy number, $G_{rT}=\frac{\rho g\alpha d^2(T_1-T_0)}{\mu c}$ is the local temperature Grashof number, $G_{rm}=\frac{\rho g\alpha^* d^2(\varphi_1-\varphi_0)}{\mu c}$ is the local mass Grashof number, $D_f=\frac{D_m\rho(\varphi_1-\varphi_0)k_T}{C_s c_p\mu(T_1-T_0)}$ is the Dufour number, $P_r=\frac{\mu c_p}{k}$ is the Prandtl number, $S_c=\frac{\mu}{\rho D_m}$ is the Schmidt number, $S_r=\frac{D_m k_T\rho(T_1-T_0)}{T_m\mu(\varphi_1-\varphi_0)}$ is the Soret number, $\beta=\frac{d^2 Q_0}{k(T_1-T_0)}$ is the dimensionless heat source/sink parameter and $p_1=\frac{dp}{dx}$ is the pressure gradient.

The dimensionless boundary conditions are:

$$\left.\begin{array}{lllll} u=0, & T=0 & \text{and} & \varphi=0 & \text{at} \quad y=-\eta \\ u=0, & T=1 & \text{and} & \varphi=1 & \text{at} \quad y=\eta \end{array}\right\}. \tag{25}$$

3. NUMERICAL TREATMENT

We can expand equations (21-23) with the boundary conditions (25) as follows:

$$nA_1\left(\frac{1}{2}\frac{u_{i+1}-u_{i-1}}{2h}\right)^{n-1}\frac{u_{i+1}-2u_i+u_{i-1}}{h^2}-\frac{1}{D_a}(u_i+1)+G_{rT}T_i+G_{rm}\varphi_i=p_1, \tag{26}$$

$$\frac{T_{i+1}-2T_i+T_{i-1}}{h^2}+D_f P_r\frac{\varphi_{i+1}-2\varphi_i+\varphi_{i-1}}{h^2}+\beta=0, \tag{27}$$

$$\frac{1}{S_c}\frac{\varphi_{i+1}-2\varphi_i+\varphi_{i-1}}{h^2}+S_r\frac{T_{i+1}-2T_i+T_{i-1}}{h^2}=0, \tag{28}$$

Where:

$$\left.\begin{array}{llll} u[-\eta]=0, & T[-\eta]=0 & \text{and} & \varphi[-\eta]=0 \\ u[\eta]=0, & T[\eta]=1 & \text{and} & \varphi[\eta]=1 \end{array}\right\}. \tag{29}$$

To have the solution of equations (26-28) under the boundary conditions (29), a standard explicit finite difference technique is used to determine the velocity, temperature and concentration. The effects of various parameters entering the problem are discussed with the help of graphs. Actually, due to the big size of the detailed solution we'll only show the graphical representations of these solutions here.

4. NUMERICAL RESULTS AND DISCUSSION

This study considers the effects of wall properties on peristaltic transport of Herschel-Bulkley fluid through porous medium in a symmetric two-dimensional vertical channel with heat and mass transfer. The equations of momentum, energy and concentration have been solved numerically by using explicit finite difference technique. The velocity, temperature and concentration distributions are calculated for different values of the tension parameter E_1, the mass parameter E_2, the damping parameter E_3, Prandtl number P_r, Schmidt number S_c and Soret number S_r, the local temperature Grashof number G_{rT} and the local mass Grashof number G_{rm}.

The effect of physical parameters on the velocity distribution is indicated through Figs. (2-8). In these figures the velocity distribution u is plotted against the coordinate y. Figs. (2) and (3) illustrate the effects of the tension parameter E_1 and the mass parameter E_2. It is found that the velocity at fixed values of y increases with increasing both E_1 and E_2. The effects of the damping parameter E_3 are to decrease the velocity which is shown in Fig. (4). It's found from Figs. (5-8) that the velocity u at fixed values of y increases by increasing the Darcy number D_a, the local temperature Grashof number G_{rT}, the local mass

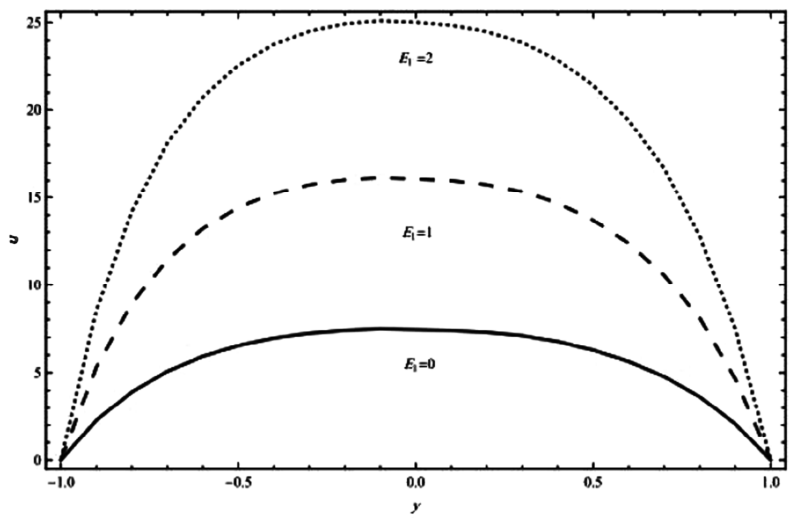

Figure 2: The Velocity Distribution u is Plotted Against y for Different Values of E_1 when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

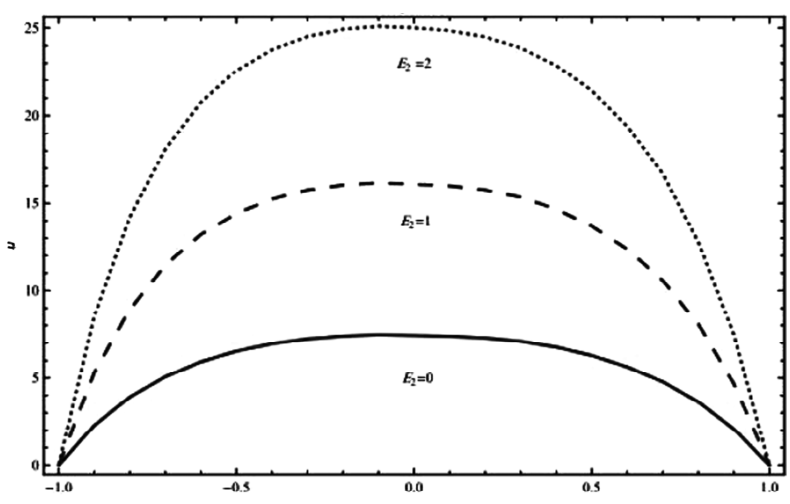

Figure 3: The Velocity Distribution u is Plotted Against y for Different Values of E_2 when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

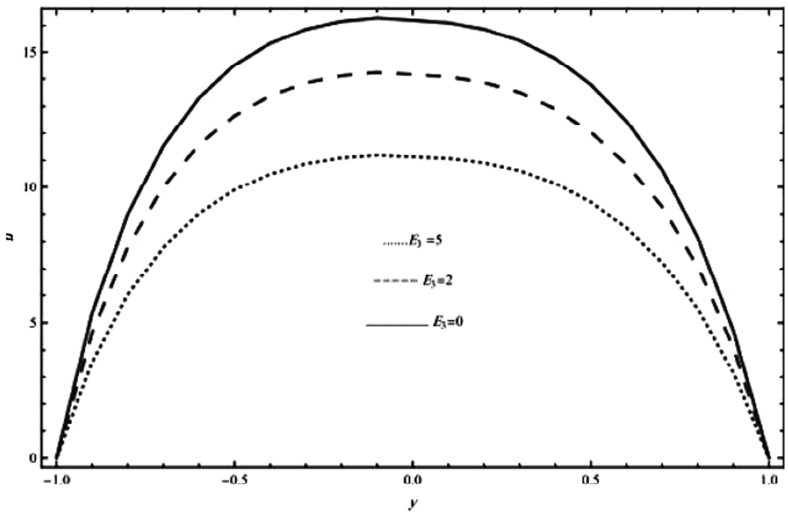

Figure 4: The Velocity Distribution u is Plotted Against y for Different Values of E_3 when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_1 = 1$, $E_2 = 1$, $x = 0.2$, $t = 0.1$

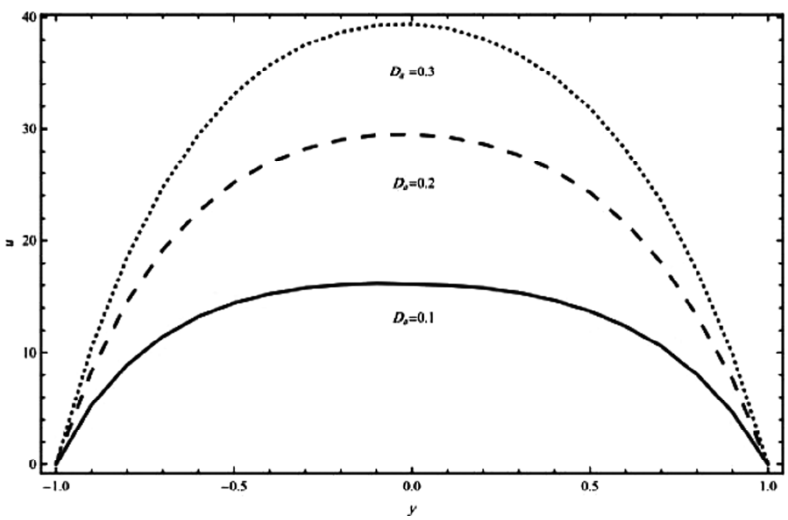

Figure 5: The Velocity Distribution u is Plotted Against y for Different Values of D_a when $\epsilon = 0.5$, $E_1 = 1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_3 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

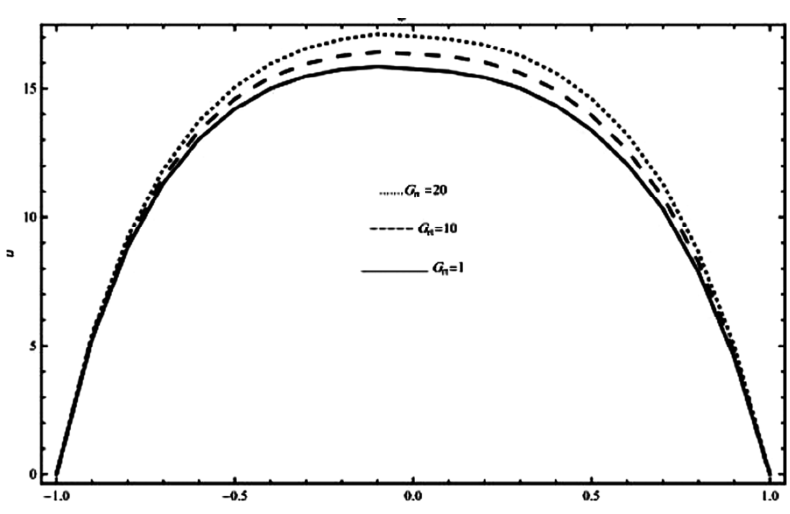

Figure 6: The Velocity Distribution u is Plotted Against y for Different Values of G_{rT} when $\epsilon = 0.5$, $D_a = 0.1$, $E_1 = 1$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

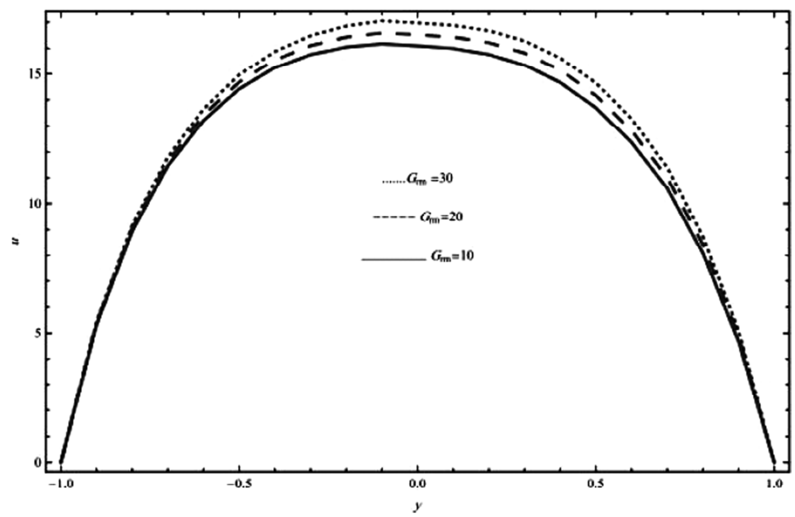

Figure 7: The Velocity Distribution u is Plotted Against y for Different Values of G_{rm} when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $E_1 = 1$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

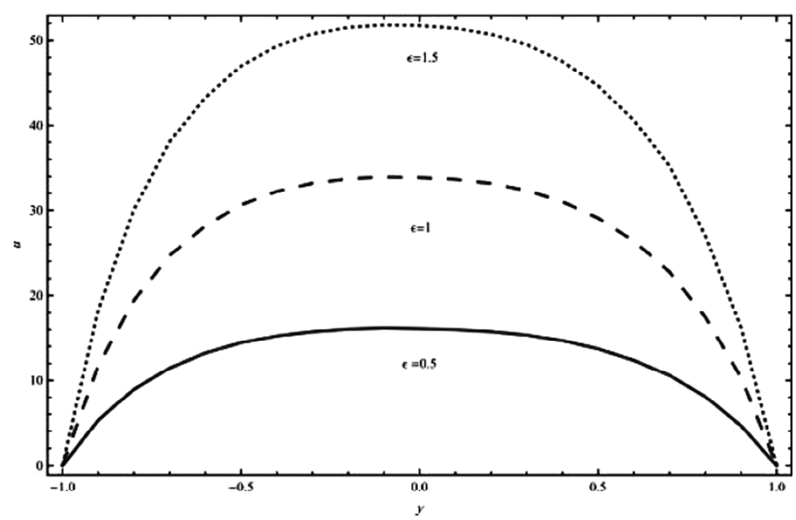

Figure 8: The Velocity Distribution u is Plotted Against y for Different Values of ϵ when $G_{rm} = 10$, $D_a = 0.1$, $G_{rT} = 6$, $E_1 = 1$, $D_f = 0.3$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

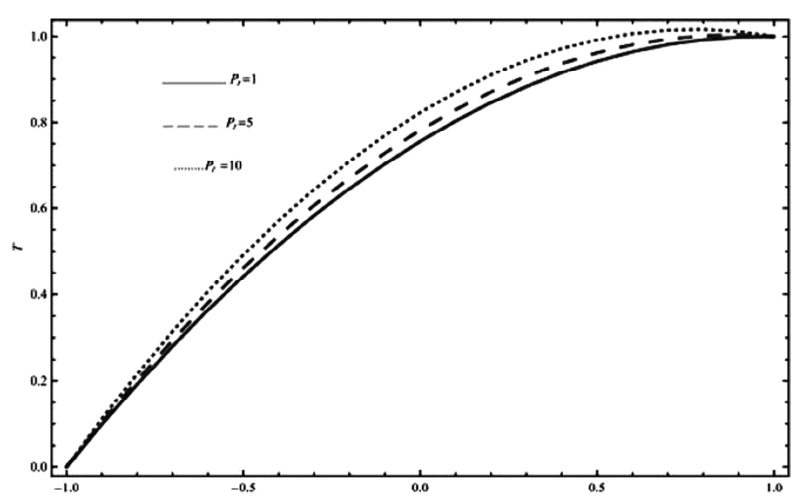

Figure 9: The Temperature Distribution T is Plotted Against y for Different Values of P_r when $\epsilon = 0.5$, for $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $\beta = 2$, $S_c = 0.15$, $S_r = 0.5$, $E_1 = 1$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

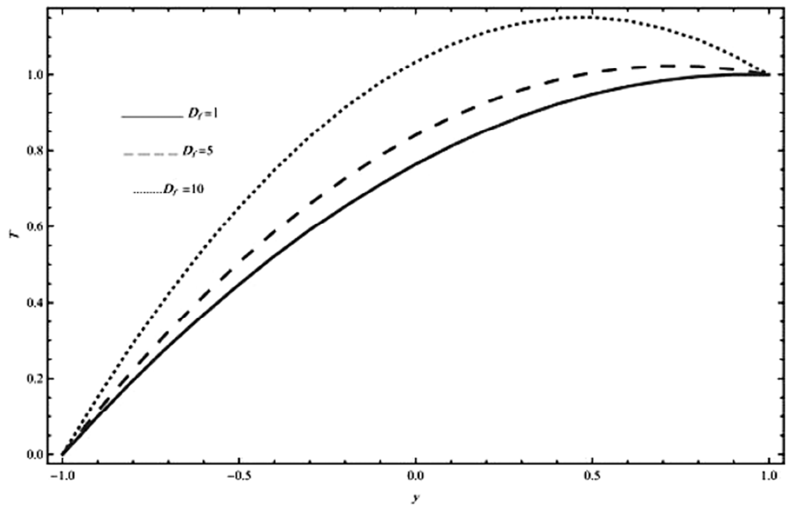

Figure 10: The Temperature Distribution T is Plotted Against y for Different Values of D_f when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $\beta = 2$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_1 = 1$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

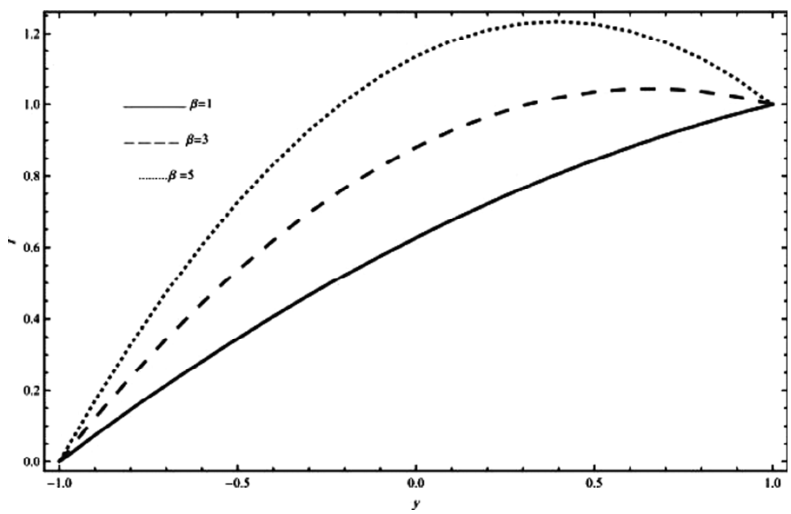

Figure 11: The Temperature Distribution T is Plotted Against y for Different Values of β when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $P_r = 0.71$, $S_c = 0.15$, $S_r = 0.5$, $E_1 =1$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

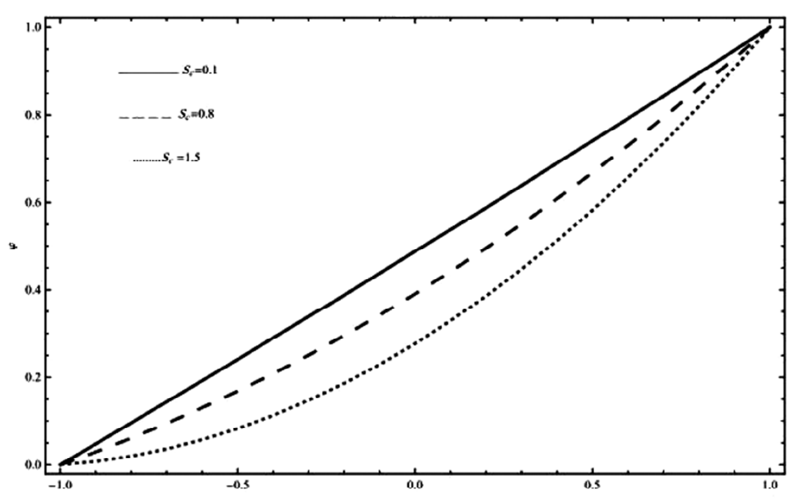

Figure 12: The Concentration Distribution C^* is Plotted Against y for Different Values of S_c when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $P_r = 0.71$, $\beta = 2$, $S_r = 0.5$, $E_1 = 1$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

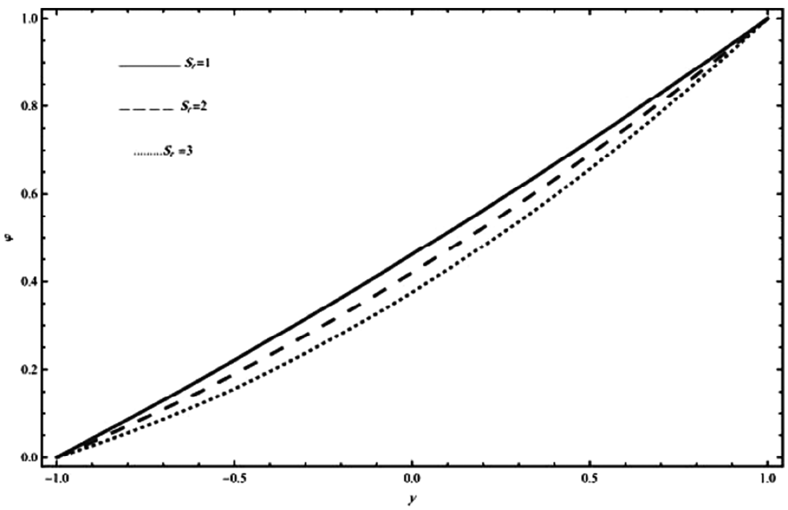

Figure 13: The Concentration Distribution C^* is Plotted Against y for Different Values of S_r when $\epsilon = 0.5$, $D_a = 0.1$, $G_{rT} = 6$, $G_{rm} = 10$, $D_f = 0.3$, $P_r = 0.71$, $\beta = 2$, $S_c = 0.15$, $E_1 = 1$, $E_2 = 1$, $E_3 = 0.1$, $x = 0.2$, $t = 0.1$

Grashof number G_{rm}, the amplitude ratio ϵ. The effects of different parameters on temperature distribution T are indicated graphically through Figs. (9-11). In Fig. (9) we observed that the temperature distribution T increases with the increase of the Prandtl number P_r. The effects of the Dufour number D_f and the dimensionless heat source/sink parameter β on the temperature distribution T are clearly depicted in Figs. (10) and (11). It is seen that T increases as S_c and S_r increase. Figs (12) and (13) are graphed to illustrate the effects of the Schmidt number S_c and Soret number S_r on the concentration distribution. It is found that φ decreases with the increases of both S_c and S_r.

5. CONCLUSION

A numerical study is made to obtain the solution of the system of deferential equations which describe the peristaltic transport of Herschel-Bulkley fluid through porous medium in a symmetric twodimensional vertical channel under the effect of wall properties with heat and mass transfer. The equations of momentum, energy and concentration are solved by using an explicit finite difference scheme. In the case of long wavelength and low Reynolds number, numerical calculations are presented for the velocity, temperature, concentration distributions and their dependence on the material parameters of the fluid. The effect of problem's parameters such as the tension parameter E_1, the mass parameter E_2, the damping parameter E_3, Darcy number D_a, Dufour number D_f, Prandtl number P_r, Schmidt number S_c and Soret number S_r, the local temperature Grashof number G_{rT} and the local mass Grashof number G_{rm} these distributions are discussed by a set of graphs. Peristaltic transport plays an indispensable role in transporting many physiological fluids in the body such as urine transport from kidney to bladder and vasomotion of small blood vessels. Also many modern mechanical devices have been designed on the principle of peristaltic pumping for transporting fluids without internal moving parts, for example, the blood pumping in the heartlung and the peristaltic transport of noxious fluid in nuclear industry.

REFERENCES

[1] C. Sankad, and G. Radhakrishnamacharya, (2009), "Influence of Wall Properties on the Peristaltic Motion of a Herschel-Bulkley Fluid in Channel", *ARPN J. of Engineering and Applied Sciences*, **10**: 27-35.

[2] S. Sreenadh, S. Rajender, and Y. Kumar, (2011), "Flow of Herschel-Bulkley Fluid in an Inclined Flexible Channel Lined with Porous Material Under Peristalsis", *International J. of Innovative Technology and Creative Engineering*, **7**: 24-35.

[3] C. Vasudev, U. Rajeswara, M. Subba, and G. Prabhakara, (2010), "Effect of Heat Transfer on Peristaltic Transport of a Newtonian Fluid Through a Porous Medium in an Asymmetric Vertical Channel", *European J. of Scientific Research*, **1**: 79-92.

[4] C. Vasudev, U. Rajeswara, G. Prabhakara, and M. Subba, (2011), "Peristaltic Flow of a Newtonian Fluid Through a Porous Medium in a Vertical Tube Under the Effect of Magnetic Field", *Int. J. Cur. Sci. Res.*, **3**: 105-110.

[5] N. Eldabe, A. El-Saka, and A. Fouad, (2004), "Thermal-Diffusion and Diffusion-Thermo Effects on Mixed Free-Forced Convection and Mass Transfer Boundary Layer Flow for Non-Newtonian Fluid with Temperature Dependent Viscosity", *Applied Mathematics and Computation*, **152**: 867-883.

[6] A. Abd El Naby, and M. El-Kareem, (2007), "The Flow Separation Through Peristaltic Motion for Power-Law Fluid in Uniform Tube", *Applied Mathematical Sciences*, **26**: 1249-1263.

[7] T. Hayat, and M. Javed, (2010), "Exact Solutions to Peristaltic Transport of Power-Law Fluid in Asymmetric Channel with Compliant Walls", *Appl. Math. Mech. Eng. Ed.*, **10**: 1231-1240.

[8] A. Kavitha, R. Hemadri, S. Sreenadh, and R. Saravana, "Peristaltic Flow of Williamson Fluid in an Asymmetric Channel Through Porous Medium", *International J. of Innovative Technology and Creative Engineering*, **1**: 48-53.

[9] T. Hayat, F. Abbasi, and A. Hendi, (2011), "Heat Transfer Analysis for Peristaltic Mechanism in Variable Viscosity Fluid", *Chin. Phys. Lett.*, **4**: 1-3.

[10] C. Casudeu, U. Rajeswara, M. Subba, and G. Prabhakara, (2010), "Peristaltic Pumping of Williamson Fluid Through a Porous Medium in a Horizontal Channel with Heat Transfer", *American J. of Scientific and Industrial Research*, **3**: 656-666.

[11] A. Medhavi, (2008), "The Peristaltic Pumping of a Non-Newtonian Fluid", *Int. J. of Applications and Applied Mathematics*, **1**: 137-148.