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A STUDY OF PERISTALTIC FLOW OF A COUPLE STRESS FLUID IN AN INCLINED CHANNEL UNDER THE EFFECT OF MAGNETIC FIELD

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ABSTRACT

In this paper we study the peristaltic flow of a couple stress fluid in an inclined channel with the effect of magnetic field.

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1. INTRODUCTION

The study of couple stress fluid is very useful in understanding various physical problems because it possesses the mechanism to describe rheological complex fluids such as liquid crystals and human blood. By couple stress fluid, we mean a fluid whose particles sizes are taken into account, a special case of non-Newtonian fluids. Srivastava et.al. [1983] peristaltic transport of a physiological fluid: part I flow in non- uniform geometry.

The advantage of decomposition method is that it can provide analytical approximation to a rather wide class of nonlinear (and stochastic) equations without linearization, perturbation, closure approximations, or discretization methods which can result in massive numerical computation. The usually desired closed-form analytical solutions of a nonlinear problem necessitate making some simplifying and restrictive assumptions in order to make it solvable.

The present research aim is to investigate the interaction of peristalsis for the flow of a couple stress fluid in a two dimensional inclined channel with the effect of magnetic field by Adomian decomposition method. The computational analysis has been carried out for drawing velocity profiles, pressure gradient and frictional force.

2. MATHEMATICAL FORMULATION

We consider a peristaltic flow of a Couple stress fluids through two-dimensional channel of width 2a and inclined at an angle α to the horizontal symmetric with respect to its axis. The walls of the channel are assumed to be flexible.
The wall deformation is

$$H(x,t) = a + bCos(\frac{2\pi}{\lambda}(X - ct)) \quad (1)$$

Where 'b' is the amplitude of the peristaltic wave, 'c' is the wave velocity, 'λ' is the wave length, t is the time and X is the direction of wave propagation.

The governing equations are

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

$$\rho(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}) = -\frac{\partial p}{\partial x} + \mu\nabla^2 u - \eta^*\nabla^4 u + \rho g \sin\alpha - \sigma B_o^2 u \quad (3)$$

$$\rho(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}) = -\frac{\partial p}{\partial y} + \mu\nabla^2 v - \eta^*\nabla^4 v - \rho g \cos\alpha - \sigma B_o^2 v \quad (4)$$

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

u and v are velocity components, 'p' is the fluid pressure, 'ρ' is the density of the fluid, 'μ' is the coefficient of viscosity, 'η^*' is the coefficient of couple stress, 'g' is the gravity due to acceleration, 'α' angle of inclination, 'σ' is electric conductivity and '$B_\circ$' is applied magnetic field.

Introducing a wave frame (x, y) moving with velocity c away from the fixed frame (X, Y) by the transformation

$$x = X - ct, y = Y, u = U, v = V, p = P(X,t) \quad (5)$$

We introduce the non-dimensional variables:

$$x^* = \frac{x}{\lambda},\ y^* = \frac{y}{a}, u^* = \frac{u}{c},\ v^* = \frac{v}{c\delta},\ t^* = \frac{tc}{\lambda}, p^* = \frac{pa^2}{\mu c\lambda}, G = \frac{\rho g a^2}{\mu c}, M = B_\circ\sqrt{\frac{\sigma}{\mu a^2}}, \phi = \frac{b}{a} \quad (6)$$

Equation of motion and boundary conditions in dimensionless form becomes

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (7)$$

$$\operatorname{Re}\delta(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}) = -\frac{\partial p}{\partial x} + (\delta^2\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}) - \frac{1}{\gamma^2}(\delta^2\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2})(\delta^2\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}) - M^2 u + G\sin\alpha \quad (8)$$

$$\operatorname{Re}\delta^3(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}) = -\frac{\partial p}{\partial y} + \delta^2(\delta^2\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}) - \frac{1}{\gamma^2}\delta^2(\delta^2\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2})(\delta^2\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}) - M^2\delta^2 v - \rho g\delta\cos\alpha \quad (9)$$

Where, $\gamma^2 = \frac{\eta^*}{\mu a^2}$ couple-stress parameter and $M^2 = B_o^2\frac{\sigma}{\mu a^2}$ Hartmann number.

The dimensionless boundary conditions are:

$$\frac{\partial u}{\partial y} = 0; \quad \frac{\partial^2 u}{\partial y^2} = 0 \quad at \quad y = 0$$

$$u = -1; \frac{\partial^2 u}{\partial y^2} \ finite \ \ at \ \ y = \pm h = 1 + \phi Cos[2\pi x] \quad (10)$$

3. RESULTS AND DISCUSSIONS

In this section we have presented the graphical results of the solutions axial velocity u, pressure rise ΔP, friction force F for the different values of couple stress (γ), magnetic field (M), angle of inclination (α), gravitational parameter (G). The axial velocity is shown in **Figs. (1 to 4)**.

The Variation of u with γ, we find that u depreciates with increase in γ (**Fig1**). The Variation of u with magnetic field M shows that for u decreases with increasing in M (**fig 2**).The Variation of u with angle of inclination α shows that for u increases with increasing in α (**Fig 3**). The Variation of u with gravitational parameter G shows that for u increases with increasing in G (**Fig 4**).

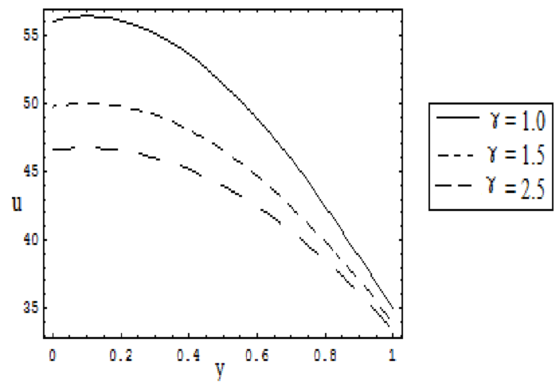

Fig. 1: Effect of γ on u, when ϕ=0.2,x=0.1 & p=-25, G= 6, M =1 & $\alpha = \pi/4$.

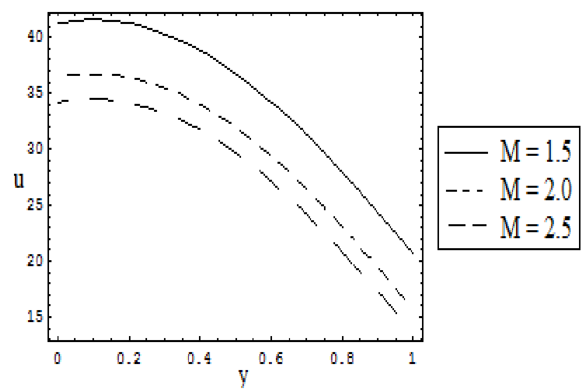

Fig. 2: Effect of **M** on u,when γ =1,ϕ=0.2,x=0.1,p=-25,G=4,$\alpha = \pi/4$,ϕ=0.2

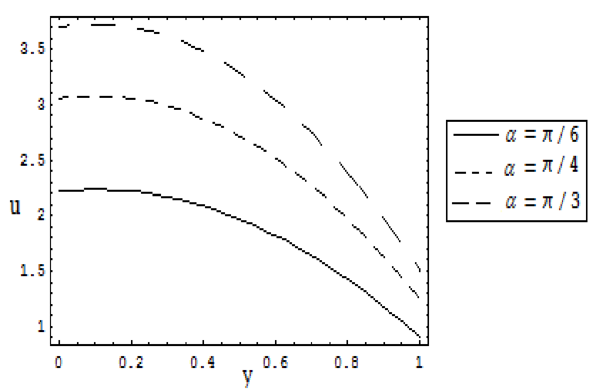

Fig. 3: Effect of α on u, when γ =3,ϕ=0.2,x=0.1,p=-.25, M=5, G= 6

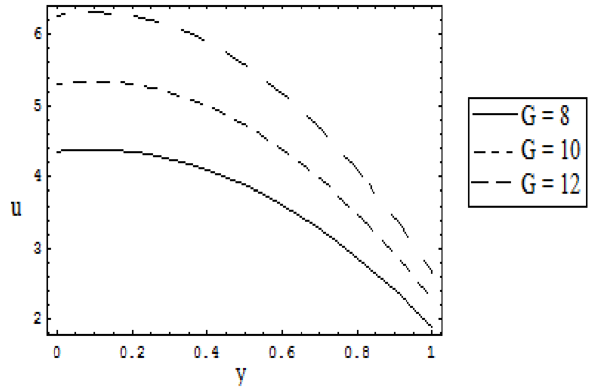

Fig. 4: Effect of G on u, when γ =1,ϕ=.2,x=0.1, p=-.25, M =1, & $\alpha = \pi/4$.

4. CONCLUSION

In this paper we presented a theoretical approach to study the peristaltic flow of a couple stress fluid in an inclined channel with the effect of a magnetic field by Adomian decomposition method. The governing Equations of motion are solved analytically. Furthermore, the effect of various values of parameters on Velocity, Pressure rise and Friction force have been computed numerically and explained graphically.

We conclude the following observations:

1. The velocity u increases with increasing in gravitational parameter G, angle of inclination α , but, decreases with increasing in couple stress parameter γ & magnetic field M.
2. The pressure ΔP increases with increasing in gravitational parameter G, angle of inclination α , couple stress parameter γ & magnetic field M.
3. The friction force F decreases with increasing in gravitational parameter G, angle of inclination α , couple stress parameter γ & magnetic field M.

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CONFLICT OF INTEREST

None.

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