UNSTEADY PERISTALTIC FLOW OF TWO IMMISCIBLE FLUIDS IN AN ELASTIC TUBE UNDER THE EFFECT OF ELECTROMAGNETIC FORCE AND OUTER REGION WITH THE POROUS MEDIUM

J. Sangeetha [1a], R. Ponalagusamy [1b] and R. Tamilselvi[1b]

[a] Department of Mathematics, National Institute of Technology, Tiruchirappalli-620015, India
[b] Department of Mathematics, National Institute of Technology, Tiruchirappalli-620015, India
[a] Corresponding author, E-mail: sangeethajagan009@gmail.com

1. OBJECTIVE

To formulate the flow pattern of two immiscible fluids in a circular tube having porous media under the effect of electromagnetic force. The analysis of the present model was carried out in the form of flow flux, pumping phenomena and elastic modulation by assuming the wall of the tube undergoes peristaltic motion with elastic nature consisting of core fluid as electrically non-conducting Jeffrey fluid and the peripheral region as an electrically conducting Newtonian fluid.

2. INTRODUCTION

In recent years, the problems based on the rheology of fluids are becoming widely popular in various fields such as Industries, biological and engineering fields. Apart from single model fluid, two or multiphase flow of fluids make it more reliable for many applications. The application of immiscible fluid (Newtonian and non-Newtonian) is in the vast range such as oil seepage in-ground, movement of food in the alimentary canal, and the flow of blood through a stenosed and normal artery. Here, we construct the model which undergoes wall deformation due to peristaltic nature in the presence of elastic nature will be defined as

$$\tilde{R}^* = R_0^* + b^* \sin\frac{2\pi}{\lambda^*}(\tilde{Z}^* - c^* t^*)$$

where, R_0^* , b^*, λ^* , $c^*$and t^* are tube radius without elasticity, the amplitude of the wave, the wavelength, velocity of the wave propagation and time. The respective elastic properties are

$$L^* = m^* \frac{\partial^2}{\partial t^{*2}} + D^* \frac{\partial}{\partial t} + B^* \frac{\partial^4}{\partial z^{*4}} - T^* \frac{\partial^2}{\partial z^{*2}} + K^*$$

where m^*, D^* , B^*, T^* and K^* denoted the mass/unit area, damping viscosity of the membrane, the flexural rigidity of the wall, the elastic tension of the wall and the spring stiffness. The corresponding constitutive equation of the Jeffrey model is

$$\tilde{\tau}^*_{\tilde{r}^*\tilde{z}^*} = \frac{\mu^*}{1+\bar{\lambda}}\left[1 + \lambda_2{}^*\left(\tilde{u}_i{}^*\frac{\partial}{\partial \tilde{r}^*} + \tilde{w}_i{}^*\frac{\partial}{\partial \tilde{z}^*}\right)\right]\left(\frac{\partial \tilde{w}_i{}^*}{\partial \tilde{r}^*} + \frac{\partial \tilde{u}_i{}^*}{\partial \tilde{z}^*}\right)$$

where, $\tilde{\tau}^*_{\tilde{r}^*\tilde{z}^*}$ is are the stress components of the corresponding plane direction. μ^* is the viscosity of corresponding fluids. $\bar{\lambda}$ is the ratio of relaxation and retardation times. $\lambda_2{}^*$ is the delay time, $\tilde{u}_i{}^*$, $\tilde{w}_i{}^*$ are velocity components and $\tilde{r}^*$, $\tilde{z}^*$ are direction components.

3. PROBLEM FORMULATION

The unsteady motion of two-layer immiscible fluid flowing through the elastic tube in the effect of peristaltic nature has been considered. The flow was considered in a cylindrical coordinate system ($\tilde{r}^*$, $\tilde{\theta}^*$, $\tilde{z}^*$) and the fluids were characterized as laminar, incompressible, viscous, axisymmetric and fluid flow in axial direction ($\tilde{z}^*$). Due to the peristaltic wave nature, the tube possesses the nature of long wavelength and low Reynolds number approximation. The nature of the immiscibility can be studied by the fluid present in the core region is taken as non-Newtonian Jeffrey fluid which is electrically non-conducting whereas, the fluid present in the outer region is taken as electrically conducting Newtonian fluid. The outer region was formulated by the Darcy equation due to the presence of the porous medium. The electric and magnetic fields were applied externally to the tube. The governing equation of the above model can be transformed into a dimensionless form by using suitable non-dimensional quantities. To obtain the analytical solution of the governed equation, the boundary conditions can be chosen as physically acceptable and mathematically constructible.

4. METHOD OF SOLUTION

From the non-dimensionless governed equation, the solution for the volumetric flow rate, the theoretical flux, pumping phenomena and its elastic nature can be expressed analytically. Due to the elastic nature of the tube, it may be undergone some kind of resistivity depending on the materials. This resistivity of the wall can be modelled into a special kind of governing equation in terms of its pressure The effects of various parameters on the pattern of fluid flow have been investigated and results are presented graphically.

5. CONCLUSIONS

We investigate the combined influence of a ratio of relaxation and retardation times, delay time, viscosity, electric field, magnetic field, Darcy number and Elastic parameter arising from the presence of elastic nature with peristaltic effect on the flow characteristics namely, volumetric flow flux, pumping characteristics, theoretical flux and elastic nature variations. The outcomes of the present study are summarized as follows:

- The influence of the ratio of relaxation and retardation time, electric field, Darcy number and Magnetic field was observed and found that the velocity of fluid flow is increased for the ratio of relaxation and retardation time, electric field, Darcy number increases whereas increasing the magnetic field tends to reduce the velocity of fluids.
- The effect of an external electric field possesses dual nature in the interfacial region and the wall region
- The impact of the Elastic parameters was made which affect the amount of flow in the fluid pattern.

REFERENCES

1. T. W. Latham, *Fluid motions in a peristaltic pump*, Ph.D Thesis, 1966.
2. S. I. Rubinow, Joseph B. Keller, “Flow of a viscous fluid through an elastic tube with applications to blood flow”, J. *theor. Biol.* **35**, pp. 299-313, 1972.
3. K. Vajravelu, S. Sreenadh, P. Devaki, K. V. Prasad, “Mathematical model for a Herschel-Bulkley fluid flow in an elastic tube”, *Cent. Eur. J. Phys.* **9**, pp.1357-1365, 2011.
4. Ponalagusamy R, Murugan D, “Effect of electro-magneto-hemodynamic environs on dispersion of solute in the peristaltic motion through a channel with chemical reaction, wall properties and porous medium”, *Korea-Australia Rheology Journal*, **34**, pp.69-90, 2022