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Effect of Chemical reaction on Peristaltic blood flow of a Magneto-Jeffrey fluid with thermal radiation in a tapered asymmetric channel

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Abstract: In this paper, we investigate the effect of chemical reaction on peristaltic flow of a Jeffrey fluid in a tapered asymmetric channel with induced magnetic field and thermal radiation. The flow is analysed by long wavelength and low Reynolds number approximations. The reduced equations are solved by using the Adomian Decomposition Method and the expressions for velocity, stream function axial induced magnetic field and pressure gradient are obtained. The effect of pertinent parameters are illustrated graphically.

Keywords: Peristaltic transport, Magneto-Jeffrey fluid, chemical reaction, thermal radiation, tapered asymmetric channel.

1. Introduction

One of the major chemical mechanisms for fluid transport in many biological systems well known to physiologists is peristalsis. Peristalsis is a mechanism of series of wave-like muscle contractions and relaxations that moves bio-fluids in different processes. Some examples of peristaltic phenomenon include urine movement from kidney to gallbladder, bile transport in duct, chyme transport in small intestine, food processing in digestive tract, flow of blood in small vessels, locomotion of worms and many others. Peristalsis finds numerous applications in medical and industrial systems which include various devices like rollers, hose and tube pumps, dialysis, open-heart by pass and heart-lung machines etc. Latham [1] was the first who initially investigated the motion of fluid in peristaltic pump. Shapiro et al. [2] studied the peristaltic activity for flow of viscous fluid in a tube and channel employing the long wavelength and low Reynolds number approximations. Some recent contributions describing the peristaltic mechanism of Newtonian and non-Newtonian fluids may be mentioned in references [3-7].

Recently, peristaltic flow with magnetic particles has grabbed the attention of several researchers due to its emerging applications in engineering and medical processes. MHD (Magnetohydrodynamics) is employed in magnetic drug targeting, pumping of blood, reduction of bleeding during surgery, continue casting process, hyperthermia, magnetic resonance imaging (MRI) and magnetotherapy etc. Few of the industrial applications include heat exchangers, pump meters, radar systems, magnetic devices for cell separation, magnetic drug targeting and magnetic tracers. Kothandapani and Srinivas [8] investigated the peristaltic transport of a Jeffrey fluid under the effect of magnetic field. Later Hayat and Ali [9] studied the influence of magnetic field on Jeffrey fluid in a tube, Vajravelu et.al [10] analysed the peristaltic transport of a conducting Jeffrey fluid in an inclined asymmetric channel. Mahmouda et.al [11] explained the MHD peristaltic transport of a Jeffrey fluid in a porous medium.

The topic of blood flow (or Hemodynamics) problems have received a considerable attention due to its major importance in physiopathology. For a long time, blood is treated as a vital fluid. Blood circulation performs various types of function in the human body such as transport of nutrients, transport of oxygen, removal of metabolic products and removal of carbon dioxide. Mekheimer [12] examined the effects of magnetic field on peristaltic blood flow of couple stress fluid in a non-uniform channel. Akbar [13] analyzed the blood flow of Prandtl fluid model in tapered stenosed arteries.

Matter interacts to form new products through a process called chemical reaction. Everyday a lot of chemical reactions takes place in the human body. Furthermore various industrial processes include chemical reactions such as Haber's process (chemical binding of Nitrogen from air to make ammonia), disinfectant (chemical treatment to kill bacteria and viruses) and pyro processing (chemically combine materials like cement).Barika and Dash [14] studied the chemical reaction effect of a magneto-micropolar fluid in a porous medium. Hayat et.al [15] analysed the chemical reaction in peristaltic transport of a MHD couple stress fluid with Soret and Dufour effects. Hayat et.al [16] have analysed the Jeffrey fluid model for convective boundary conditions.

In thermodynamics, thermal radiation also known as heat is the emission of electromagnetic waves from all matter that has a temperature greater than absolute zero. Heat transfer takes place in the human body by conduction, convection, evaporation and radiation. Transport of heat by the circulatory system makes heat transfer in the body. Ajaz et.al [17] analysed the radiation effects on micropolar fluid. Hayat et.al [18] studied the entropy generation rate for a peristaltic pump of a Jeffrey fluid. Selvi et.al. [19] discussed the effect of heat transfer on peristaltic flow of Jeffrey fluid in an inclined porous stratum. Asha and Deepa [20] analysed the entropy generation for peristaltic blood flow of a magneto-micropolar fluid with thermal radiation in a tapered channel.

The word taper means diminish or reduce in thickness towards one end. The tapered asymmetric channel is normally created due to the intra-uterine fluid flow induced by myometrical contractions and it was stimulated by asymmetric peristaltic fluid flow in a two-dimensional channel. Ajaz [21] studied the peristaltic flow of nanofluids in a tapered asymmetric porous channel. Asha and Deepa [22] discussed the micro polar fluid flow in a tapered asymmetric channel. Asha and Deepa [23] analysed the impacts of hall and heat transfer with peristalsis. Asha and Deepa [24] also reported the thermo- diffusion and diffusion-thermo effects with peristaltic flow.

In view of the above discussion the aim of this study is to analyse the chemical reaction effect on peristaltic blood flow of a magneto-Jeffrey fluid with thermal radiation in a tapered asymmetric channel. The Jeffrey model is relatively simpler linear model using time derivatives instead of convected derivatives, it represents a rheology different from the Newtonian. The problem is first modelled and then analysed by the long wavelength and low Reynolds number approximations. The reduced governing equations are solved by using the Adomian Decomposition Method (ADM) and the effect of various parameters are discussed and illustrated graphically.

2. Mathematical modelling

Consider the peristaltic flow of an incompressible, viscous and electrically conducting magneto-Jeffrey fluid through a tapered asymmetric two dimensional channel with thermal radiation effects. The flow is generated by sinusoidal wave trains propagating with constant speed ‘c’ along the channel walls.

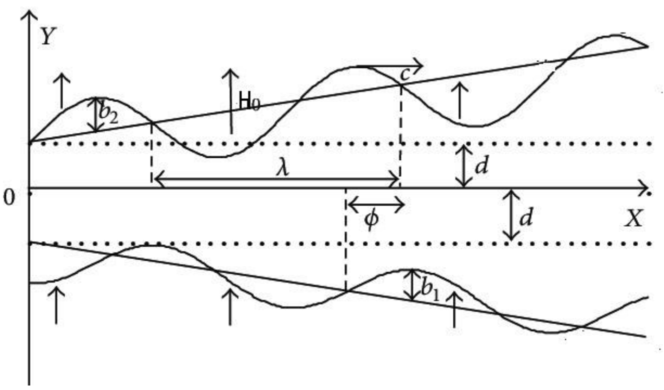

Figure 1 A physical sketch of the problem

We consider a rectangular coordinate system for the channel in which the X-axis is taken along the centreline of the channel and the Y-axis is transverse to it. An external transverse uniform constant magnetic field H_0, induced magnetic field $H^{'}(h_x^{'}, h_y^{'}, 0)$ and therefore the total magnetic field $H^{'+}(h_x^{'}, H_0 + h_y^{'}, 0)$, where $h_x^{'}$ and $h_y^{'}$ are the components of induced magnetic field along the co-ordinated axes. The geometry of the wall surfaces is given by,

$$h'_1(X', t') = d + m'X' + a_1 sin\left[\frac{2\pi}{\lambda}(X' - ct')\right], \text{ upper wall} \quad (1)$$

$$h'_2(X', t') = -d - m'X' - a_2 sin\left[\frac{2\pi}{\lambda}(X' - ct') + \phi\right], \text{ lower wall} \quad (2)$$