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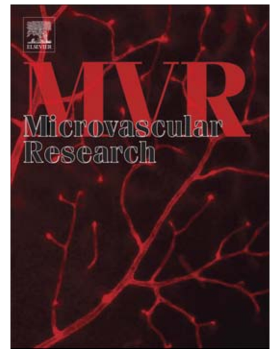

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N.K. Ranjit, G.C. Shit, D. Tripathi

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Joule heating and zeta potential effects on peristaltic blood flow through porous micro vessels altered by electrohydrodynamic

N. K. Ranjit[a], G. C. Shit[b*], D. Tripathi[c]

a Department of Mathematics, Techno India, Salt Lake, Sec V, Kolkata- 700091, India.
b Department of Mathematics, Jadavpur University, Kolkata - 700032, India.
c Department of Mechanical Engineering, Manipal University Jaipur, Rajasthan 303007, India
[*] Corresponding Author. Email: gopal_iitkgp@yahoo.co.in (G. C. Shit), Tel. Phone: +91 33 2457 2716

Abstract

In most of the medical therapies, electromagnetic field plays important role to modulate the blood flow and to reduce the pain of human body. With this fact, this paper presents a mathematical model to study the peristaltic blood flow through porous microvessels in presence of electrohydrodynamics. The effects of Joule heating and different zeta potential are also considered. Darcy law is employed for porous medium. The mathematical analysis is carried out in the form of electroosmosis, flow analysis and heat transfer analysis. Velocity slip conditions are imposed to solve momentum equation and thermal energy equation. Time dependent volumetric flow rate is considered which varies exponentially. Closed form solutions for potential function is obtained under Debye-H*ü*ckel approximation and velocity and temperature fields are obtained under low Reynolds number and large wavelength approximations. The influence of Hartmann number, electroosmotic parameter, slip parameters, Zeta potential, and couple stress parameter on flow characteristics, pumping characteristics and trapping phenomenon are computed. The effects of thermal slip parameters, Joule heating parameter, and Brinkman number on heat transfer characteristics are also presented graphically. Finally, the effect of Brinkman number on a graph between Nusselt number and Joule heating parameter is examined.

Keywords: Peristaltic motion, Couple stress fluid, Porous microvessel, Electro-magneto-hydrodynamics, Zeta Potential, Joule heating

1. Introduction

Magnetohydrodynamics (MHD) is the study of dynamics in the presence of external applied magnetic field which has wide range of applications in biomedical sciences [1] like magnetic drug targeting, magnetic devices for cell separation, adjusting blood flow during the surgery, transporting complex bio-waste fluids, cancer tumour treatment, magnetic endoscopy, and hyperthermia. Some magnetohydrodynamics models [2]-[9] on peristalsis are presented with various type of fluid models like Jeffrey fluid model [2], Johnson-Segalman fluid [3], Sisko fluid [4], micropolar fluid [5], couple stress fluid [6, 7], hyperbolic tangent fluid [8], and Ree-Eyring fluid model [9]. The effects of Hartmann number on flow characteristics are discussed. The results indicated that the peristaltic flow can be altered by using the magnetic field which can be used to develop the techniques for magneto-peristaltic pumps. Peristalsis is a biological mechanism which acts as a pump and creates a negative pressure gradient to push the biological fluids from one part to another part of the living organs.
In all the above studies, the theory magnetohydrodynamics is considered in peristaltic transport of Newtonian and non-Newtonian fluids through various flow regimes (Rectangular duct, symmetric and asymmetric channel, tube, porous medium, etc.). However, the less attention has been paid to examine the effects of electrohydrodynamics (EHD). The applications of EHD in urology [10] and peristalsis [11]-[16] have attracted the attention of many researchers of biomedical science and engineering. The first theoretical model on peristaltic flow augmented through the electroosmosis was developed by Chakraborty [11]. In this model, thin electrical double layer (EDL) assumption (electroosmotic velocity is taken as slip velocity at the wall) was considered. This model was further modified without