Ascendancy of electromagnetic force and Hall currents on blood flow carrying Cu-Au NPs in a non-uniform endoscopic annulus having wall slip

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Abstract

This article aims to outline the characteristics of the blood flow conveying copper (Cu) and gold (Au) nanoparticles (NPs) through a non-uniform endoscopic annulus with wall slip under the action of electromagnetic force and Hall currents. The flow of blood with the suspension of hybrid nanoparticles in the annulus is induced by the peristaltic pumping. The governing equations are modeled and then simplified with the postulate of lubrication theory. The resulting non-dimensional momentum equation after simplification is solved analytically by employing the He's homotopy perturbation method (HPM) with the computational software *Mathematica program (version 11)*. The influential role of emerging physical parameters on the physiological features related to the blood flow is inferred graphically and physically. The analytical outcomes reveal that Hall parameter has a diminishing behavior on the blood flow while the inverse impact is endured for mounting Hartmann number. Electromagnetic field and Hall currents offer a superlative mode for regulating blood flow at the time of surgery. An increment in the volume fraction of nanoparticles causes a drop in the blood temperature profile. The trapping phenomenon is also explored with the help of contours. An expansion in Hartmann number reduces the size of entrapped bolus and ultimately vanishes when Hartmann number is very large. This prospective model may be applicable in electromagnetic micro-pumps, medical simulation devices, heart-lung machine (HLM), drug carrying and drug transport systems, cancer diagnosis, tumor selective photothermal therapy, etc.

Introduction

An ongoing interest in understanding the blood flow dynamics under the strong electromagnetic force and the concentration of nanoparticles has opened a new direction of evolution in biomedical as well as bioengineering disciplines. Electro-magneto-hydrodynamics (EMHD) is a cardinal branch of fluid mechanics and it has immense emergence in bioengineering and biomedical fields in recent decades. It refers to study electro-magnetic properties and flow characteristics of ionized fluids such as blood, saliva, Cerebrospinal fluid, synovial fluid, digestive fluids, physiological fluids, food, etc. Blood is a complex rheological biofluid that transports necessary ingredients such a nutrients and oxygen to the cells whereas drives away cellular waste products from the same cells (Ganong, 2003). In invertebrates, blood is composed of cellular components suspended in plasma which contains proteins, glucose, mineral ions, hormones, carbon dioxide, fibrin, etc. (Chakraborty, 2019). The suspension of blood cells in plasma gives it peculiar physiological and rheological characteristics. The impacts of EMHD on blood flow are significant and have challenging propositions in clinical science, for example, blood diagnosis, urine diagnosis, blood plasma separation, blood siphon machines, malignant growth tumor treatment causing hyperthermia, transport of medication, etc. (Chakravarty and Mandal, 2000). EMHD principles may be pertinent to the blood flow dynamics since blood is an electrically conducting fluid. EMHD plays a vital role in improving the performance of electromagnetic fluid pumps, lab-on-a-chip devices, and micro-fabricated fluid devices, etc. In this respect, some investigations have been reported for the attentive readers (Mekheimer et al., 2011; Shit, 2013; Alshare et al., 2013; Ellahi et al., 2015; Reddy et al., 2019; Riaz et al., 2020a).

Drug carrying and drug transportation inside physiological systems have to be needed a strong magnetic field force. Hall effect is pertinent when the applied magnetic field is