Significance of Hall currents on hybrid nano-blood flow through an inclined artery having mild stenosis: Homotopy perturbation approach

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Abstract

The rheological perspective of blood flow with the suspension of metallic or non-metallic nanoparticles through arteries having cardiovascular diseases is getting more attention due to momentous applications in obstructed hemodynamics, nano-hemodynamics, nano-pharmacology, blood purification system, treatment of hemodynamic ailments, etc. Motivated by the novel significance and research in this direction, a mathematical hemodynamics model is developed to mimic the hemodynamic features of blood flow under the concentration of hybrid nanoparticles through an inclined artery with mild stenosis in the existence of dominating electromagnetic field force, Hall currents, heat source, and porous substance. Copper (Cu) and copper oxide (CuO) nanoparticles are submerged into the blood to form hybrid nano-blood suspension (Cu-CuO/blood). The attribute of the medium porosity on the blood flow is featured by Darcy's law. The mathematical equations describing the flow are formulated and simplified under mild stenosis and small Reynolds number assumptions. To determine the analytical solution of the resulting nonlinear momentum equation, the homotopy perturbation method (HPM) is employed. Several figures are graphed to assess the hemodynamical contributions of various intricate physical parameters on blood flow phenomena through the inclined stenosed artery. Significant outcomes from graphical elucidation envisage that the hemodynamic resistance to the blood flow is reduced due to the dispersion of more hybrid nanoparticles in the blood. The hemodynamic resistance (impedance) increases approximately two times by dispersing 0.11% hybrid nanoparticles in the blood flow. The temperature of Cu-CuO/blood is found to be lower in comparison to Cu-blood and pure blood. Intensification of Hall parameter attenuates the wall shear stress at the arterial wall. The trapping phenomena are also outlined via streamline plots which exemplify the blood flow pattern in the stenosed artery under the variation of the emerging parameters. As anticipated, the addition of a large number of hybrid nanoparticles significantly modulates the blood flow pattern in the stenotic region. The novel feature of this model is the impressive impact of Hall currents on hybrid nanoparticle doped blood flow through the stenosed artery. There is another piece of significance is that HPM is the

Introduction

Nanofluids expand ongoing consideration because of their outstanding thermal features and prospective applications in medical science. This has led researchers and scientists to carry out their work towards the improvement of the thermal properties of conventional working liquids. Nanofluid is a mixture of metallic or non-metallic nanometer-sized (1 nm–100 nm) solid particles and the base fluid like water, ethylene glycol, oils, polymer solutions, blood, etc. It has been established that a uniform dispersion of nanomaterials in a base fluid boosts the thermal characteristics. Additionally, volume fraction, type, size, and shape of nanoparticles are also being considered to maximize the thermal conductivity of conventional working fluids. Nanofluids are being successfully utilized in the diverse area of applications like microelectronics, solar cells, nuclear reactors, space technology, blood diagnosis, urine diagnosis, processing of generic drugs, nano-medicine, lithotripsy, and cancer treatment, nano-pharmacological delivery systems (Abbas et al., 2016). Cu (copper, metal) nanoparticles possess unique optoelectrical properties and high thermal conductivity and CuO (copper oxide, metal oxide) nanoparticles have shown high toxicity, chemical inertness as well as stability when compared to many other metallic and metal oxide nanoparticles. Copper oxide nanoparticles are relatively cheap and photocatalytic concerning their chemical and physical properties and used as anti-infective agents due to their larger surface area and desirable crystal morphologies. They exhibit antibacterial action against various strains of bacteria. Hence, Cu and CuO nanoparticles are useful in many physiological and medical implications. In stenotic hemodynamics, the blood is considered as the base liquid and a variety of nanoparticles are doped in it. Different coatings of nanomaterials and controlled-release nano-carriers are deployed to prevent in-stent restenosis and to improve the performance of current stents (Dubey et al., 2020). Choi et al. (2001) first time proposed the concept of nanofluids. He reported that the insertion of nanomaterials as a suspension in conventional heat transfer liquids significantly enhances the thermal conductivities and heat transfer performance. His pioneer research study motivated many researchers to