

Analysis of blood through trapping vertical porous annulus with cilia in the presence of thermal radiation

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Abstract. This study describes the analysis of nanofluid flow due to trapping along porous annulus with cilia in the presence of thermal radiation and heat absorption effects. In this examination, a partial differential equation is formulated to represent the two-dimensional movement of nanofluid. This system is developed in the cylindrical coordinates system and thereafter, a long wavelength approximation is introduced to attain the simplified form of the system. Emerging parameters are attained with nanoparticle's effects in the system. Effective thermal conductivity models for heat transfer analysis are utilized. Numerical solution has been calculated for pressure rise and pressure gradient. Velocity and temperature distribution is also plotted for physical parameters. It is important to find that the trend of velocity is increasing by improving the quantity of nanoparticle concentration, radiation and mixed convection parameters. By increasing the size of the radius, velocity profile and pressure gradient have decreasing trend.

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Key words: Porous annulus, nanoparticles, heat absorption, thermal radiation, trapping arteries.

1 Introduction

Peristalsis stands as a significant mechanism responsible for the mixing and transportation of fluids. It emerges from the propagation of a sequential pattern of contraction and expansion along the inner surface of a tube. This intricate process facilitates the movement of fluids from regions of lower pressure to those of higher pressure, enabled by the

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advancing wave of contraction and expansion along the tube's pliable wall. This peristaltic mechanism serves various physiological functions, including transporting urine from the kidney to the bladder via the ureter, conveying chyme within the gastrointestinal tract, propelling spermatozoa through the ductus efferentes of the male reproductive tract, guiding the ovum along the fallopian tube, aiding in cilia transport, and maintaining blood circulation within narrow blood vessels. Moreover, peristaltic pumping finds practical application in numerous scenarios involving biomechanical systems. For specialized purposes, finger and roller pumps are commonly utilized to handle corrosive or exceptionally pure substances, ensuring that the fluid remains separate from the pump's internal surfaces. Additionally, leveraging the principles of peristalsis has led to the creation of various biomechanical instruments, such as the heart-lung machine.

Latham [1] was the first who made study for peristaltic flow. Later on Shapiro [2] explained this phenomenon in two dimensional flow. He considered the flow as inertia free with small wavelengths. Barton and Raynor [3] discussed peristaltic motion of two dimensional flow in tubes. They assumed a small Reynolds number. Shapiro et al. [4] talked about the peristaltic flow for both planar and axisymmetric cases. They applied the condition of long wavelength and very small Reynolds number. Yin and Fung [5] studied peristaltic pumping in the coordinate channel and axisymmetric tube. They assumed the condition of small wave length and low Reynolds number. Jaffrin [6] examined the inertia and streamline curvature impact on peristaltic flow. Jaffrin and Shapiro [7] represented peristaltic flow in distinctive routines. They studied peristaltic motion in the presence of pressure gradients. For circular cylindrical tubes peristaltic pumping is deliberated by Takabatake et al [8]. In another study Mekhiemer [9] examined the peristaltic movement of couple stress within a ring-shaped region using an endoscope.

Cilia are microscopic hair-like structures found in the respiratory, digestive, and reproductive systems of both males and females, as well as in the nervous system across various animal species. They hold significant functions in processes such as movement, locomotion, feeding, circulation, breathing, and reproduction. Cilia primarily serve to transport fluids, utilizing their synchronized beating to create a metachronal wave. This wave-like motion, resulting from the coordinated movement of cilia, is facilitated by the flexible envelope of cilia tips. This envelope, forming the metachronal wave, acts as a stretchable barrier, consistently propelling forward motion in a singular direction.

Agrawal and Anawaruddin [10] talked about cilia transference of biofluid with variable thickness. Barton and Raynor [11] discussed mucus flow due to motion of cilia. [12,13] analysed hydrodynamics of protozoa that they utilize cilia for movement. Vélez-Cordero and Lauga [14] explained the envelope model of cilia by taking Newtonian fluid. Mechanical features of cilia were presented by Rydholm et al. [15]. Basten and Giles [16] discussed function of cilia. Nadeem and Sadaf [17] analyzed the ciliary motion in annulus with nanofluid. Nonetheless, the exploration of ciliary motion within a porous medium containing nanofluid remains largely uncharted. Consequently, the primary aim of this research is to delve into the theoretical examination of nanofluid behavior within a porous annulus, driven by a metachronal wave of cilia, while also accounting