ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Spl Iss 2, 2021

Effects of Heat and Mass Transfer on Magnetohydrodynamic (MHD) Casson Fluid Flow in a Stretching Permeable Vessel Containing Blood.

T tarun teja, Dept of mechanical, Koneru Lakshmaiah Education Foundation, India-522302

Abstract

This paper presents a theoretical analysis of blood flow incorporating heat and mass transport, influenced by time-dependent magnetism and Casson fluid behavior. The study focuses on the intricate dynamics of unsteady, nonlinear partial differential equations (PDEs) governing blood flow. By employing similarity transformations, the governing nonlinear equations for motion, energy, and concentration are transformed into ordinary differential equations (ODEs). The solution process involves utilizing the Runge-Kutta Fehlberg method and a shooting procedure to solve the resulting ODE system. The study delves into the impact of various physical parameters, including Casson fluid behavior, permeability, Prandtl number, Hartmann number, thermal radiation parameter, chemical reaction parameter, and Schmidt number. These parameters are analyzed graphically with respect to flow variables, namely blood velocity within the vessel, blood temperature, and blood concentration. Key findings from the simulation study include a decrease in blood flow velocity with increasing magnetic and unsteadiness parameters. This research stands out by investigating unsteady blood flow within a slender, permeable vessel, accounting for the influence of time-dependent magnetism. The study's uniqueness lies in its exploration of two-dimensional, unsteady blood flow within a stretched vessel, a novel perspective that has not been previously elucidated.

Introduction

As blood circulates through our veins, it transports heat to different areas of our body. Heat transfer within the blood can occur through various mechanisms, including conduction, convection, and radiation. Radiation involves the transfer of energy via electromagnetic waves and can take place in specific regions of space [1]. An interesting experimental observation reveals that radiant heat transport is directly proportional to the absolute temperature, while conduction and convection are linked to linear temperature differences [2]. Several factors contribute to the amount of thermal energy transferred during blood flow. These factors include the thermal energy transport coefficient of the blood, its density, velocity, and the radius of the blood vessel [3]. Furthermore, the temperature of the surrounding tissues also plays a significant role in influencing these factors. The impact of thermal radiation on blood flow has numerous implications in the field of medical research and applications [4-6]. It finds relevance in areas such as biomedical engineering, radiotherapy, MRI (Magnetic Resonance Imaging), CT scan (Computed Tomography), echocardiography, and Doppler ultrasound. Infrared radiation, for instance, can be directly utilized in the treatment of blood-related conditions like cancer through heat therapy, targeting infected regions of the blood [7]. This approach demonstrates a broad spectrum of applications, including alleviating muscle pain and addressing muscle contractions [8-10].

Expanding upon the research conducted [11], the current study investigates the influence of mass transfer on a chemically reacting Casson fluid along a stretching sheet. This particular aspect has not been previously addressed in the existing literature. The motivation for this study is rooted in the practical utilization of intricate fluids, like blood, within the medical field. Inspired by the

ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 10, Spl Iss 2, 2021

aforementioned studies, our objective is to delve into the implications of thermal radiation and chemical reactions on magnetohydrodynamic (MHD) Casson flow of blood within a permeable vessel undergoing stretching [12]. Notably, this study focuses on scenarios where there is no velocity, thermal, or concentration variation at the vessel wall.

Blood flow analysis

Examine the circulation of blood within elongated, permeable slender conduits, where the influence of time-dependent magnetism introduces an unsteady, two-dimensional characteristic. This scenario involves the Casson model for the flow of a viscous, incompressible fluid exhibiting thermal radiation effects, chemical reactions, and electrical conductivity.

The constitutive condition for the Casson fluid is composed as:

$$\tau_{ij} = \begin{cases} 2(\mu_B + \frac{\tau_y}{\sqrt{2\pi}})e_{ij}, & \pi > \pi_c, \\ 2(\mu_B + \frac{\tau_y}{\sqrt{2\pi_c}})e_{ij}, & \pi < \pi_c \end{cases} \tag{1}$$

The continuity equation of the flow model takes the form

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0. \tag{2}$$

The momentum equation is of the form

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu(1+\frac{1}{\beta})\frac{\partial^2 u}{\partial y^2} - \frac{\sigma B_0^2(t)}{\rho}u - \frac{\nu}{K_1(t)}u. \tag{3}$$

The energy and concentration equations of the flow model take the form as

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} - \frac{1}{\rho Cp}\frac{\partial q_r}{\partial y}, \tag{4}$$

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D_M\frac{\partial^2 C}{\partial y^2} - Kr(C - C_\infty). \tag{5}$$

The boundary conditions of the model can be written as

$$\begin{aligned} &u = U_w, v = f_w, T = T_w, C = C_w \quad \text{at} \quad y = 0 \\ &u \to 0, T \to T_\infty, C \to C_\infty \qquad \text{as} \quad y \to \infty \end{aligned} \tag{6}$$

$$f_w = -\sqrt{(\frac{\nu V_w}{x})}S. \tag{7}$$

Time dependent chemical reaction parameter Kr(t) takes the following form

$$U_w(x,t) = \frac{ax}{1-ct}, T_w(x,t) = T_\infty + \frac{bx}{1-ct}, C_w(x,t) = C_\infty + \frac{bx}{1-ct}, Kr(t) = \frac{Kr}{1-ct} \tag{8}$$

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Spl Iss 2, 2021

Methodology

The converted nonlinear differential Equations with the boundary conditions are elucidated by Runge-Kutta Fehlberg method along with shooting technique.

Then,

$$y_3' = \left[\frac{A\left(y_2 + 0.5\eta y_3\right) + \left(M + \frac{1}{K}\right) y_2 - y_1 y_3 + y_2^2}{\left(1 + \beta^{-1}\right)}\right],$$

$$y_5' = -\Pr\left[\frac{\left(y_1 y_5 - y_2 y_4 - A\left(y_4 + 0.5\eta y_5\right)\right)}{\left(1 + R\right)}\right],$$

$$y_7' = Kr y_6 - Sc\left(y_1 y_5 - y_2 y_5 - A\left(y_5 + 0.5\eta y_7\right)\right),$$

$$y_1(0) = S, y_2(0) = 1, y_4(0) = 1, y_6(0) = 1, y_2(\infty) = 0, y_4(\infty) = 0, y_6(\infty) = 0.$$

Results

In this investigation, we have conducted a comprehensive theoretical analysis of blood circulation, incorporating both heat and mass transfer effects, in the presence of time-dependent magnetism and Casson fluid dynamics. We have applied a uniform magnetic field aligned with the flow direction, as the blood is modeled as a Casson fluid with electrical conductivity. This choice is motivated by the blood's magnetohydrodynamic (MHD) nature.

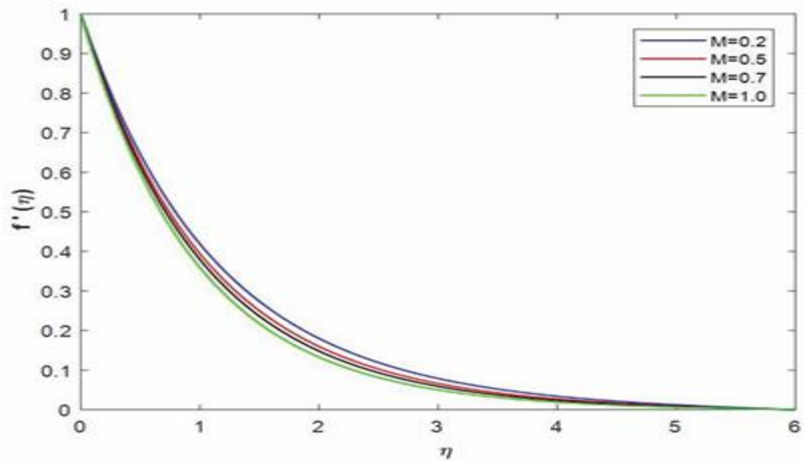

Fig. 2 Impact of M on velocity profile.

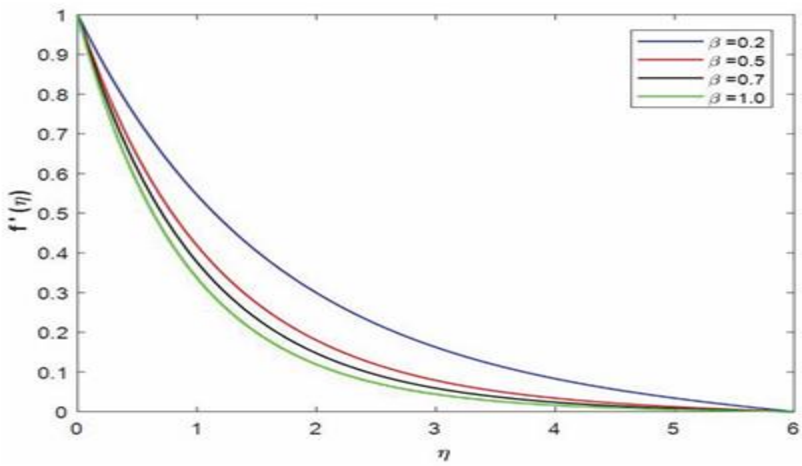

Fig. 3 Impact of β on velocity profile.

Conclusions

The key discoveries of this research are as follows:

1. Elevated values of M, β, A, and S result in a degeneration of the velocity profile.

2. Higher values of K intensify the velocity profile.

3. Increased values of Pr and A lead to a reduction in the temperature profile.

4. Larger values of R gradually elevate the temperature profile.

5. Enhanced values of A, Sc, and Kr lead to a deterioration of the concentration profile.

References

[1] Prakash, J.and Makinde, O.D. (2011), Radiative heat transfer to blood flow through a stenotic artery in the presence of magnetic field, Lat Am Appl Res,41,273-277.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 10, Spl Iss 2, 2021**

[2] He, Y., Shirazaki, M., Liu, H., Himeno, R., andSun,Z.(2006),A numerical coupling model to analyze the blood flow, temperature, and oxygen transport in human breast tumor under laser irradiation, Computers in BiologyandMedicine,36,1336-1350.

[3] Ogulu, A. andBestman, A.R. (1994), Blood flow in a curved pipe with radiative heat transfer, Acta Physica Hungarica,74,189-201.

[4] Misra,J.C.,Sinha,A.,and Shit,G.C.(2010),Flow of a biomagnetic viscoelastic fluid: application to estimation of blood flow in arteries during electromagnetic hyperthermia, atherapeutic procedure for cancer treatment,AppliedMathematicsandMechanics,31,1405-1420.

[5] Hernandez,T.(1983),Alligator metabolism studies on chemical reactions in vivo, Comparative biochemistry And physiology PartB: Comparative biochemistry,74(1),1-175.

[6] Xu, Z., Chen, N., Shadden, S.C., Marsden, J.E., Kamocka, M.M.,Rosen,E.D.,and Alber,M.(2009),Study Of blood flow impact on growth of thrombi using a multi scale model, SoftMatter,5(4),769-779.

[7] Sharma,M.andGaur,R.K.(2017),Effect of variable viscosity on chemically reacting magneto-blood flow With heat and mass transfer, Global Journal of Pure and Applied Mathematics,13(3),26-35.

[8] Vankan, W.J., Huyghe, J.M., Drost, M.R., Janssen, J.D., and Huson, A. (1997), A finite element mixture Model for hierarchical porous media, International Journal for Numerical Methods in Engineering,40,197 210.

[9] Dash, R.K., Mehta, K.N., and Jayaraman,G.(1996),Casson fluid flow in a pipe filled with homogeneous Porous medium, International Journal of Engineering Science,34,1146-1156.

[10] Preziosi,L.andFarina,A.(2002),On Darcy’s law for growing porous media, International Journal of Non Linear Mechanics,37,485-491.

[11] Pal, B., Misra, J.C., andGupta,A.S.(1996),Steady hydromagnetic flow in a slowly varying channel, Proceedings-National Academy of Sciences, India. Section A, Physical Sciences,66,247-262.

[12] Misra,J.C.andShit,G.C.(2009),Biomagnetic viscoelastic fluid flow over a stretching sheet, Applied Mathematics and Computation, 210,350-361.