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Magneto hybrid nanofluid flow with activation energy and chemical reaction through an impermeable stretching elastic cylinder

Amit Sarkar [a] and Kalidas Das [b]

[a]Department of Mathematics, S.A. Jaipuria College, Kolkata, West Bengal, India; [b]Department of Mathematics, Krishnagar Government College, Krishnagar, West Bengal, India

ABSTRACT
This article focuses on the study of incompressible, steady, and electrically-conducting hybrid-nanofluid flow through an impermeable stretching elastic cylinder. The base fluid chosen for the study is water and two nanoparticles, namely *Cu* and graphene, are used for the hybrid nanofluid, while Cu is used for the usual nanofluid. The system takes into account the presence of a chemical reaction, activation energy, and a magnetic field. A comparative analysis is performed to examine the impact of these factors on the hybrid nanofluid and usual nanofluid. The governing equations are transformed into non-dimensional form using similarity transformation and solved using the RK-4 method. The study utilizes graphs and tables to analyse the influence of relevant factors on the flow profile. The results indicate that the temperature decreases with the activation energy factor but increases with the chemical reaction and curvature factors. Both heat and mass transport processes are enhanced by the activation energy parameter, while the opposite effect is observed for the chemical reaction parameter.

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Hybrid nanofluid; magnetic field; activation energy; chemical reaction; elastic stretching cylinder

1. Introduction

Thermal management and heat transport analysis have become crucial concerns for engineers, scientists, and researchers due to their diverse applications in technological fields and industries dealing with high thermal energy. As technology and energy production continue to advance, engineers are striving to develop efficient lubricants and coolants. Unfortunately, traditional fluids like water, kerosene, and glycerol are inadequate in meeting these demands due to their low thermal conductivity, resulting in limited heat transport capabilities. However, a promising solution lies in the addition of minute metallic particles (with diameters ranging from 1 to 100 nm) to the base medium, significantly enhancing the resulting liquid's thermal conductivity. Such revolutionary fluids are known as 'nanofluids,' a term coined by Choi [1]. Since that time, in-depth inquiries have been underway to uncover the concealed potential applications of nanofluids. In recent research, Khan et al. [2] studied the entropy generation of steady nonlinear Sisko nanofluid flow over a stretchable rotating disk with viscous dissipation and heat source. Their findings revealed that higher values of the Brinkman number and diffusion lead to increased entropy generation rate. Another investigation by Sarkar and Kundu [3] focused on double-diffusive free convection nanoliquid flow over an inclined plate placed in a porous medium. In a separate study, Khan et al. [4] examined the Soret and Dufour effects on non-Newtonian Carreau Yasuda Fluid flow over a porous stretchable surface. Their results indicated that increasing the Dufour number decreases the fluid temperature, while the Soret number increases the concentration. Sarkar and Kundu [5] investigated natural convective flow along a vertical plane sheet in a Darcy-Forchheimer porous medium with copper nanoparticles. They considered a transverse magnetic field and solar radiation in their model and reported that fluid temperature increases with the surface convection parameter, while the porous medium parameter and inertial parameter lead to the opposite trend. Numerous researchers have also explored the hydrothermal and heat transfer characteristics of the fluid flows over different geometries [6–9].

Recently, there has been a growing interest among researchers worldwide in an extended version of nanofluid known as 'hybrid nanofluid.' This innovative fluid consists of double metallic nanoparticles dispersed within the host fluid. The incorporation of these dual metallic additives makes hybrid nanofluid particularly effective for heat transfer and coolant applications. Due to its unique properties, hybrid nanofluid finds valuable applications in various sectors, such as aerospace technologies, nuclear reactors, solar receivers, biomedical

CONTACT Amit Sarkar amitformath@gmail.com Dept. of Mathematics, S.A. Jaipuria College, Kolkata 700005, India
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