Biointerface Research in Applied Chemistry
Open-Access Journal (ISSN: 2069-5837)

Article
Volume 13, Issue 5, 2023, 436
https://doi.org/10.33263/BRIAC135.436

A Numerical Study on Unsteady MHD Williamson Nanofluid Flow past a Permeable Moving Cylinder in the presence of Thermal Radiation and Chemical Reaction

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Received: 7.09.2022; Accepted: 7.10.2022; Published: 19.12.2022

Abstract: The current investigation considers the unsteady two-dimensional MHD flow along with heat and mass transfer of Williamson nanofluid over a moving cylinder of a porous medium. The influence of chemical reactions, thermal radiation, and Joule heating are also considered. This article will use the Buongiorno model to explore the Brownian motion heat transfer process and thermophoresis. The boundary layer governing equations is made non-dimensional by employing the usual transformation. To solve the non-linear dimensionless governing equations, a technique known as the explicit finite difference method (EFDM) is used. A stability analysis was carried out to make the approach more convergent, and an efficient criterion ($Le \geq 0.018$ and $Pr \geq 0.03$) was obtained. The influence of different parameters on the velocity, temperature, and concentration profile are illustrated graphically. From this study, we have achieved that the increase in radiation raises the temperature of the boundary layer region. Also, it was found that the speed of the hybrid nanofluid can be controlled by applying a magnetic field and porous media and enhancing Williamson parameters. To validate the accuracy of the numerical scheme, a qualitative comparison of the results obtained is made with that of the previously published works.

Keywords: Williamson nanofluid; moving cylinder; explicit finite difference method; thermal radiation; chemical reaction; porous medium.

1. Introduction

The remarkable heat transfer characteristics of nanofluid without any pressure drop have attracted a lot of attention from researchers over the past few decades. Conventional fluids have very low thermal conductivity; as a result, they cannot be used for ultra-high cooling processes. Nowadays, nanofluid is used as a base fluid instead of ordinary fluid because of its enhanced thermal properties as compared to ordinary fluid. Nanofluids are made by adding nanoparticles like Ag, Cu, Al_2O_3, etc., into the base fluid like water, ethylene glycol, etc. The idea that dispersing nanoparticles in the base fluid may improve thermal conductivity was first introduced by Choi [1]. After evaluating the thermal conductivity of various metal oxides, Lee *et al*. [2] found that both shape and size contributed significantly to the improved thermal conductivity of the nanofluid. According to the research conducted by Eastman *et al*. [3], the thermal conductivity of ethylene glycol could be increased by as much as 40% if copper nanoparticles (with a volume fraction of less than 1 percent) were added. To explain the enhancement in nanofluid's thermal conductivity, Buongiorno [4] identified Brownian motion