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A study on MHD flow of *SWCNT*-Al_2O_3/water hybrid nanofluid past a vertical permeable cone under the influence of thermal radiation and chemical reactions

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ABSTRACT

This study investigates the steady, incompressible MHD flow of a hybrid nanofluid over a vertical solid cone embedded in a porous medium under suction effect. The research explores the effects of various factors, such as thermal radiation, chemical reactions, heat generation, viscous dissipation, and Joule heating on heat and mass transfer phenomena. To investigate the effects of hybrid nanoparticles, we consider single-walled carbon nanotubes (*SWCNT*) and alumina (Al_2O_3) along with water (H_2O) as the base fluid. After a suitable similarity transformation, the governing equations are reconstructed and solved using the Keller-box numerical scheme. We present graphical and tabular analyses of various parameter impacts on heat transfer profiles and coefficients. This study provides valuable insights into the control of fluid dynamics and heat transfer in porous media, which have significant implications for industrial and engineering applications. The findings of the current article are in excellent agreement with previously published works.

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1. Introduction

Due to their exceptional ability to transport heat in a variety of engineering and commercial applications, nanofluids have attracted the interest of many researchers. Convectional fluids such as water, ethylene glycol, and engine oil are often poor heat conductors due to their poor thermal conduction, which makes them inefficient in today's modern cooling applications. Nanofluids consist of nanoscale particles such as copper, alumina, carbides, nitrides, metal oxides, graphite, and carbon nanotubes, which enhance the thermal conductivity of base fluids. The diameter of such nanoparticles may vary anywhere between 1 and 100 nm. It was Choi and Eastman [1] who first observed that nanoparticles suspended in base fluid could enhance the thermal conductivity, which in turn improved the heat transfer rate of the fluid. 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. Later, Buongiorno [3] investigated the factors that influenced the thermal conductivity of nanofluids and reported that Brownian motion and the thermophoresis effect increase the nanofluid's thermal conductivity. As a consequence of the revelation, Nield and Kuznetsov [4] used Buongiorno's model on the boundary layer stream.

Later, Khan and Pop [5] explored the steady flow of nanofluid on a stretching sheet. Using convective boundary conditions, Makinde and Aziz [6] looked into the heat transfer characteristics of nanofluid flow. Khan *et al.* [7] conducted research analyzing the rheological behavior of a nanofluid and investigating the effects of various parameters on its viscosity and other rheological

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