HYBRID NANOFLUIDS and its Model Applications

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PREFACE

Hybrid nanofluids, which combine conventional heat transfer fluids with nanoparticles, have emerged as a promising frontier, offering unprecedented opportunities for enhancing thermal performance. In heat transfer research, the exploration of hybrid nanofluids has garnered significant attention as researchers seek innovative solutions to meet the escalating demands of modern engineering applications.

This book chapter serves as a comprehensive exploration of advanced heat transfer fluids, specifically focusing on hybrid nanofluids. It encompasses six key topics that collectively contribute to our understanding of this dynamic field. The book represents a synthesis of theoretical rigor, computational analysis, and practical insights aimed at advancing our understanding of advanced heat transfer fluids, with a particular emphasis on the transformative potential of hybrid nanofluids.

We hope that this exploration will inspire further research, innovation, and collaboration in this dynamic field. Ultimately, this could lead to the development of novel solutions to address the pressing challenges of heat transfer in modern engineering applications.

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INTRODUCTION

The relentless pursuit of enhanced fluid properties by researchers is driven by their diverse applications in many aspects of our daily lives. With the progression of science and technology, nanotechnology has emerged as a key driver of innovation. This enthusiasm for advancement resonates across varied domains, including heating and cooling systems, solar collectors, biomedical devices, electronics cooling, material treatment, heat and mass transfer enhancement, heat exchangers, electrical equipment cooling, engineering device optimization, and chemical processes. These areas, particularly relevant in mechanical engineering, civil engineering, and medical physics, have garnered significant academic and industrial attention (Alagumalai et al., 2022; Sheremet, 2021; Smaisim et al., 2022; Wong & De Leon, 2010). A pivotal development in this field is the concept of nanofluid, which involves enhancing fluids with nanoparticles to improve their thermal conductivity and other intrinsic properties. This concept dates back to 1995, when Choi and Eastman (1995) presented the concept of nanofluid. These fluids contain a variety of nanoparticles, such as metals (e.g. Ag, Cu, Al), nitrides (e.g. SiN, AiN), metal carbides (e.g. SiC), oxide ceramics (e.g. CuO, Al_2O_3), and non-metals (e.g. graphite, CNTs). These particles are distributed over a range of base fluids, including as methanol, ethylene glycol, water, bio-fluids, and motor oil, as well as specialised media like kerosene oil and polymer solutions.

Thus, the present book chapter is proposed. In this book chapter, Chapter 2 delves into a mathematical examination of boundary layer flow and heat transfer phenomena in an aqueous Cu-TiO_2 hybrid nanofluid, considering the presence of viscous dissipation and magnetic fields. Through essential similarity transformations, the governing partial differential equations are transformed into ordinary differential equations, subsequently solved numerically using the bvp4c function in MATLAB. Notably, the impact of various factors such as nanoparticle concentration and magnetic field strength on heat transfer rates is investigated. The findings reveal that while an increase in nanoparticle concentration exhibits diverse effects, an augmented suction parameter reduces the boundary layer thickness, shedding light on critical aspects of hybrid nanofluid dynamics.

Furthermore, Chapter 3 explores the unsteady separated stagnation-point magnetohydrodynamic (MHD) flow of a hybrid nanofluid, considering the influence of viscous dissipation and Joule heating. Constructing a novel mathematical model for hybrid nanofluid dynamics, similarity solutions are derived in the form of ordinary differential equations (ODEs), which are then numerically solved using the bvp4c method in MATLAB. The study examines the impact of physical parameters such as nanoparticle volume fraction and unsteadiness on skin friction coefficients and heat transfer performance. Notably, the inclusion of magnetic and acceleration parameters significantly affects heat transfer rates, with implications for understanding and optimising hybrid nanofluid flow dynamics.

Chapter 4 analysed the heat transfer characteristics of two-dimensional flow of hybrid nanofluid over a horizontal plate with variable wall temperature. The study accounts for the effects of porosity, magnetic field, heat radiation, and viscous dissipation, contributing to the uniqueness of the mathematical model. Employing the Crank-Nicolson technique, the model is solved numerically, and the obtained results highlight the role of hybrid nanoparticles and magnetic fields in enhancing heat transfer, while factors such as porosity and thermal radiation parameter hinder heat transfer rates.

In Chapter 5, a hybrid nanofluid flow over a vertical Riga plate is investigated. This chapter delves into the investigation of hybrid nanofluid flow over a vertical Riga plate, utilizing the Atangana-baleanu fractional derivative to account for fractional-order derivatives. The study aims to elucidate the effects of nanoparticle composition and fractional parameters on fluid temperature and velocity. The findings underscore the significance of copper nanoparticles in enhancing fluid velocity due to their high electrical conductivity, offering insights into potential applications in marine vessels.

Finally, Chapter 6 explores the significant thermal effects of hybrid nanofluid on thin-film flow past a stretchable unsteady sheet. Focusing on alumina and copper nanoparticles suspended in ethylene glycol, the study employs similarity transformation techniques to simplify governing equations, subsequently solved using the Homotopy analysis method and Keller-box method. The analysis reveals the impact of unsteadiness, nanoparticle volume fraction, and suction intensity on thin-film thickness, providing valuable insights for enhancing thin-film flow dynamics with hybrid nanofluids.

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