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Chapter 8: Analysis of Thermal Irreversibility and Dual solutions of Casson Nanofluid flow over an Expanding Sheet under the Influence of Lorentz force and Chemical Reaction: A Stability Examination

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Abstract: This study explores the dual nature and stability of Casson nanofluid flow over a stretching surface under the influence of a magnetic field and energy transfer in terms of both heat and mass transfers. Inertial and viscous forces work together to control flow along with convective and conductive heat and mass transfer mechanisms. To assess thermodynamic irreversibility, entropy generation analysis is performed. The governing nonlinear partial differential equations are transformed using similarity variables and then numerically solved by utilizing MATLAB built-in bvp4c solver, which employs Lobatto IIIA collocation method. Both graphical and tabulated results are presented to illustrate the impact of key physical parameters on entropy generation distributions and physical quantities. Additionally, a linear stability analysis is performed to determine dual solutions' physical viability, suggesting that the first solution is stable, whereas the second solution is unstable. A key outcome of this investigation is that the proposed magneto-Casson nanofluid model offers enhanced controllability of drag force and heat transfer characteristics, making it highly suitable for advanced engineering and biomedical applications.

Keywords: Casson fluid, Entropy analysis, Chemical reaction, Magnetic field, Energy transfer, Dual solutions, Stability analysis.

Introduction

The interest of researchers in Casson nanofluids stems from their unique flow properties and a wide range of applications. The fluids can be used to cool electronics more efficiently, keep car engines running smoother and even increase the effectiveness of medicine delivery, all because of their ability to easily transfer and carry small particles. The analysis of blood flow using fluid model constitutes a better perception on blood viscosity and flow attributes. It could be used in the simulation and prediction of blood flow through blood vessels and this would assist in diagnosis and treatment plan in the health sector.

There are many authors who were interested in the influence of Casson fluid parameter, thermal radiation and the rest factors [1] [2]. The effects of heat radiation and the formation of entropy on blood of an inclined channel of magneto-micropolar fluid have been investigated in [3]. The use of magnetohydrodynamics (MHD) allowed Thirupathi *et al.* to examine the flow of a Casson nanofluid