Impact of Variable Physical Properties on Magnetized Power-Law Fluid Flow over an Inclined Plate

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1. INTRODUCTION

Non-Newtonian fluid has a wide range of application in numerous engineering fields which includes food processing, petroleum, drilling rigs, chemical, polymer, paint and adhesives, nuclear reactors, and cooling systems[1]. One of the most commonly used non-Newtonian models is the power-law fluid[2]. The analysis of heat and mass transfer in mixed convection of power-law fluid along an inclined plate with a porous medium has gained a lot of attention due to its wide range of applications in energy-related engineering problems that include both polymer and metal sheets.

Further, the combined effects of viscous dissipation and Joule heating play a vital role in numerous fields. The synthesis of materials by ejection, cooling of electronic chips, and paper manufacturing are a few real-life applications where the ultimate product of required attributes builds upon the cooling rate[3].

Most of the existing literature was studied with the assumption that the physical features of the fluid were constants. But, the presence of temperature may lead to significant variations in the physical characteristics of the fluid flow, particularly for fluid viscosity, and thermal conductivity which occurs in many natural phenomena (e.g., photosynthesis) and technological processes such as solar ponds, drying crystals, cooling process during solidification of binary alloy, and cooling of nuclear reactors, extrusion of sheet[4].

This study aims to analyze the influence of variable physical properties on magnetized power-law fluid flow over an inclined plate embedded in a porous medium. The combined effects of viscous dissipation and Joule heating are taken into consideration.

2. MATHEMATICAL MODELING

The following significant steps will be followed for the accomplishment of the mathematical modeling of the present problem.

- First, governing equations of power-law fluid flow past the inclined plate will be considered under the boundary layer conditions with Boussinesq approximation.
- Then, the governing partial differential equations are transformed into the dimensionless form using appropriate similarity variables. Also, the physical quantities in dimensionless form are derived for this study.
- Lastly, the resultant ordinary differential equations will be solved using Bvp4c (inbuilt function) in MATLABs software.

3. RESULTS AND HIGHLIGHTS

Here, the above-said numerical solutions will be utilized to the analysis fluid flow characteristics and heat transfer rates. This analysis will be made for both shear thinning and shear thickening fluids and results are represented graphically for the important parameters.

Some significant observations are pointed out below:

- An increment in variable viscosity and thermal conductivity raised the temperature of both shear thinning and shear thickening fluids.
- The viscous effect enhances both velocity and temperature which is in good agreement with the work of Swain et al [3].
- An inclination angle decreases the velocity profile due to buoyancy force but it diminishes more in the case of shear-thinning fluid compared to shear-thickening fluids.

Finally, this work is beneficial in many industrial fields including thermal energy storage, polymer extrusion processes, petroleum reservoirs, recoverable systems, and cooling of an infinite metallic plate.

REFERENCE

[1] Nabwey Hossam A. et al. "A Comprehensive Review of Non-Newtonian Nanofluid Heat Transfer." *Symmetry* 15.2 (2023): 362.

[2] Xinhui Si, Haozhe Li, Liancun Zheng, Yanan Shen, Xinxin Zhang, "A mixed convection flow and heat transfer of pseudo-plastic power law nanofluids past a stretching vertical plate", *Int. J Heat and Mass Trans.* 105, pp 350-358, 2017.

[3] B. K. Swain, B. C. Parida, S. Kar, & N. Senapati, "Viscous dissipation and joule heating effect on MHD flow and heat transfer past a stretching sheet embedded in a porous medium", *Heliyon 6*(10),2020.

[4] I.L. Animasaun, E.A. Adebile, A.I. Fagbade, "Casson fluid flow with variable thermo-physical property along exponentially stretching sheet with suction and exponentially decaying internal heat generation using the homotopy analysis method", *J. Nige. Math. Soci.* 35, pp 1-17,2016.