Nanofluid flowing past a stretching cylinder subject to Thompson and Troian slip

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1. INTRODUCTION & OBJECTIVE

The analysis of heat and mass transfer of a nanofluid flowing across a cylinder is discussed in this work. The flow is considered in the presence of non–linear velocity slip called Thompson and Troian slip at the surface of the geometry. Brownian motion and thermophoresis, which are caused due to the movement of nanoparticles in a fluid, are considered to be the two main mechanisms influencing the mass and heat transfer. Buongiorno's model is one of the models that considered these forces and their impact. This study incorporates Buongiorno's model to study the Prandtl boundary layer theory of the flow of nanofluid past a cylinder. The Prandtl boundary layer is a thin region near a solid surface in fluid flow where viscous forces are significant, causing a velocity gradient from zero at the surface to the free stream velocity.

In 1995, Choi coined the term nanofluid by suspending metallic particles with a size of $10^{-9}m$ in a base fluid. The industrial applications of nanofluid were presented by Bianco et al. [1] who observed that the use of nanofluids increased the operating energy. Heat transfer occurs whenever there is a temperature gradient within a body while mass transfer occurs whenever there is a concentration gradient. Galal et al. [2] observed a decrease in skin friction coefficient for increase in magnetic field inclination in a nanofluid flow. A cylinder is a three-dimensional geometric shape composed of two circular bases that are parallel to each other and are connected by a curving surface. The experimental results were obtained by Frikha et al. [3] for temperature distribution and the heat transfer coefficients of nanofluid. When there is a partial slip, the Thompson and Troian slip model describes the fluid flow close to a solid boundary especially with reference to nanofluidic and microfluidic systems. In the nanoscale, where conventional no-slip boundary requirements may not be correct, this model plays a crucial role in explaining how fluids behave. Thompson and Troian [4] introduced one such slip at the solid surface where the local shear rate and the quantity of slip have a general nonlinear relationship. Shaheen et al. [5] observed an increase in the temperature of the nanofluid for higher Newtonian heating.

Considering the investigation of heat and mass transfer of a nanofluid moving across a stretching cylinder with Thompson and Troian slip condition, a gap in the literature was identified. The examination of the convective heat and mass transfer circumstances, as well as the Thompson and Troian velocity slip, are the primary focus of this study. The mathematical model is created using Buongiorno's model, which places a high value on thermophoresis and Brownian motion. The governing equations are in the form of partial differential equations which are converted into ordinary differential equations using similarity transformations. The model is solved using the RKF-45 method and the results are interpreted in the form of graphs.

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2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

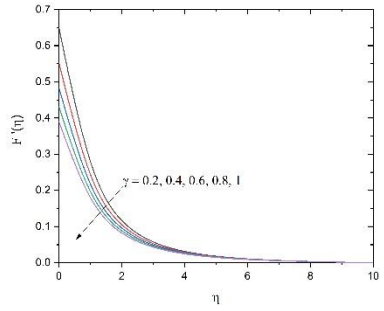

Figure 1: Effect of γ on F'(η)

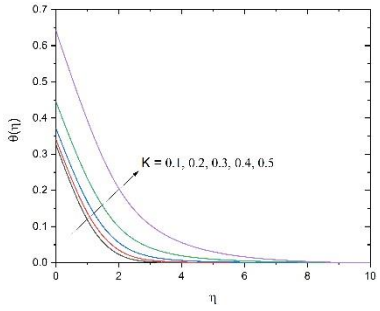

Figure 2: Effect of K on $\theta(\eta)$

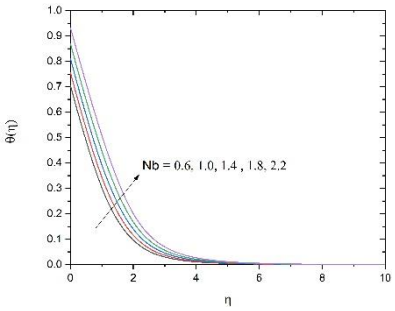

Figure 3: Effect of Nb on $\theta(\eta)$

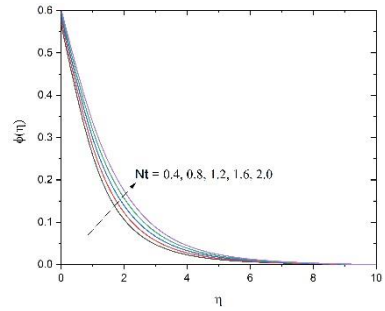

Figure 4: Effect of Nt on $\phi(\eta)$

- The higher values of the invariable slip parameter reduced the velocity of the fluid flow.
- The higher radius of curvature of the cylinder was found to conduct the transfer of more heat to the nanofluid.
- The Brownian motion contributed positively to the uniform distribution of the temperature that led to the increase in the temperature profile.
- The thermophoresis parameter enhanced the concentration profile.

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