Convective heat transfer analysis of nanofluid in the presence of gyrotactic microorganisms

Ananya V Kamath[a] and V Puneeth[a1]

[a] Department of Mathematics, CHRIST University, Bengaluru 560089, India

1. INTRODUCTION & OBJECTIVE

The Prandtl boundary layer refers to a thin region of fluid flow near a solid boundary, where the effects of viscosity are significant. This concept was introduced by Ludwig Prandtl in 1904 and forms the basis for much of modern fluid dynamics. Choi, in the year 1995 introduced the term nanofluid, a fluid that contains nanometer sized particles. The flow one such nanofluid past a stretching sheet is analysed in this study by considering the Thompson and Troian velocity slip at the boundary along with the convective heat and mass transfer. Thompson-Troian slip describes a phenomenon where a fluid exhibits slip at a solid boundary, meaning that the velocity of the fluid at the boundary is not equal to the velocity of the solid surface. This slip modifies the boundary layer behavior of the in the bioconvective flow of nanofluid [1]. Bioconvection refers to the movement in the fluid caused by the collective motion of microorganisms [2]. The presence of microorganisms in the system enables the uniform distribution of nanoparticles through their movement within the fluid. The movement of these cells will lead to bioconvection. In system where both bioconvection and heat transfer occur, the movement of microorganism can enhace the overall heat transfer [3]. The movement of microorganisms withint he nanofluid enhance the mixing causing uniform distribution of temperature [4]. Convective heat transfer involves tranfer of heat through a fluid due to bulk movement of fluid [5]. Viscous dissipation is the process by which mechanical energy is converted into thermal energy due to the internal friction of the fluid. This occurs when there is a shear in the fluid, leading to the generation of heat. Viscous dissipation contributes to the heating of the fluid due to the internal friction, and this additional heat influences the convective heat transfer process [6]. The study on nanofluid has gained a lot of interests among the researchers due to its wide range of applications in the field of automobiles, medicine, solar heat exhangers etc.

The presence of nanoparticles in the nanofluid will also contribute to the heat generated in the system. Thus, along with the presence of temperature dependent heat source, the concentration dependent heat source is also very necessary as it plays an important role. Through the literature review, it was observed that the studies considering the concentration dependent heat source was not explored widely. Thus, this study focusses on covering the gap by introducing the concentration dependent heat source that directly impacts the heat transfer properties of nanofluid. The term corresponding to this is added to the energy equation and the resulting system of partial differential equations is converted to ordinary differential equations using similarity transformation. This system of nonlinear ordinary differential equations is solved using numerical method and the outcomes are interpreted graphically.

[1] Further author information: (Send correspondence to S.S.A)

A.A.A.: ananya.kamath@maths.christuniversity.in Telephone: --

S.S.A.: puneeth.v@res.christuniversity.in, Telephone: --, Address: CHRIST University, Bangalore central campus, Bengaluru 560029, India

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

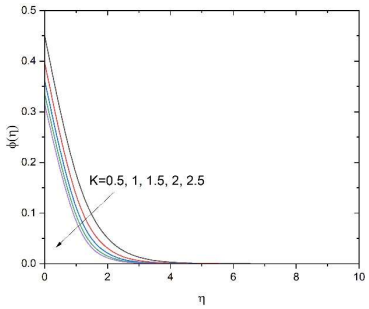

Figure 1: Effect of K on $\phi(\eta)$.

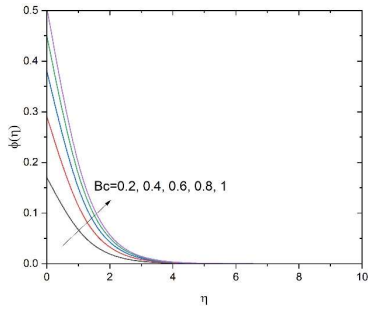

Figure 2: Effect of Bc on $\phi(\eta)$.

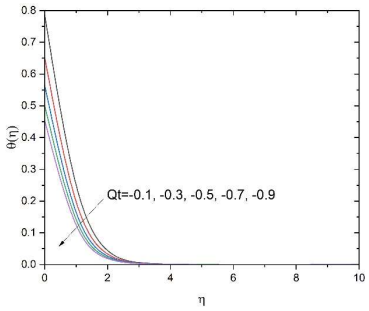

Figure 3: Effect of Qt on $\theta(\eta)$.

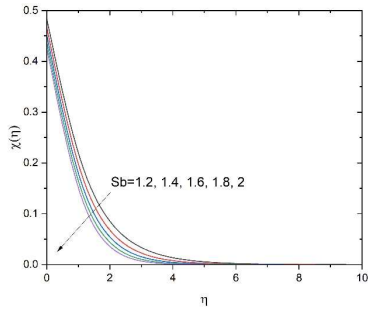

Figure 4: Effect of Sb on $\chi(\eta)$.

Conclusion:

- The increase in the chemical reaction rate decreased the concentration profile.
- The small changes in the concentration Biot number lead to a significant change in the concentration profile.
- The increase in the temperature dependent heat source enhanced the thermal profile.
- The higher values of bioconvection Schmidt number decreased the motile density profile.

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