Viscous dissipation effect on the thin film nanofluid flow under non-linear velocity slip

Shivani B K[a] and V Puneeth[a1]

[a] Department of Mathematics, CHRIST University, Bengaluru 560029, India

1. INTRODUCTION & OBJECTIVE

This study deals with the analysis of the thin film nanofluid flow in the presence of viscous dissipation and chemical reaction. The boundary of the flow is subjected to nonlinear velocity slip called Thompson and Troian slip. The presence of nanoparticles further leads to the generation of heat within the system and acts as a source. A nanofluid is a type of a fluid that contains nanometer-sized particles. Maiti and Mukhopadhyay [1] studied how a magnetic field affects the flow of nanofluid in a diverging channel. Puneeth et al. [2] examined how jet flow of Casson nanofluid with microorganisms and a magnetic field affects heat transfer and fluid behavior. Safdar et al. [3] studied the effects of various parameters on the steady MHD Maxwell nanofluid flow over a porous stretching sheet with gyrotatic microorganism, using mathematical modeling and numerical analysis. Mixed convection is a type of heat transfer that occurs due to the combined effects of both natural convection and forced convection. Lone et al. [4] how mixed convection affect the flow and heat transfer of hybrid nanofluids. Felicita et al. [5] examined how mixed convection and couple stress affect the flow and heat transfer of Casson nanomaterial in a microchannel. Dey et al. [6] examined how Stefan blowing and Thompson-Troian slip affect nanofluid flow over a flat plate where these factors imact fluid flow and heat transfer. Thomson-Troian slip refers to the boundary condition used in fluid dynamics specifically in the context of microscale and nano flows. Xin et al. [7] studied how joule heating, viscous dissipation and Thompson –Troian slip conditions affect the heat and flow behavior of nanofluid.

The presence of nanoparticles within the nanofluid will lead to reactions due to the interactions among the nanoparticles present in the base fluid. Thus the concentration equation will be affected due to these reactions. Further, the presence of nanoaprticles and their movements within the fluid will generate heat that is absorbed by the nanofluid contributing to the changes in the heat conduction. Thus, the consideration of this parameter in the energy equation is highly feasible and will be more realistic. In this regard, energy equation is modeled by considering temperature dependent heat source and concentration dependent heat source along with the viscous dissipation effect. The mathematical model is designed using the Navier Stokes equations considering these assumptions and the model is further transformed to non-linear differential equations. This resulting system is solved using the RKF-45 method and the results are interpreted in the form of graphs.

---

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

A.A.A.: E-mail: shivani.bk@maths.christuniversity.in

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

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

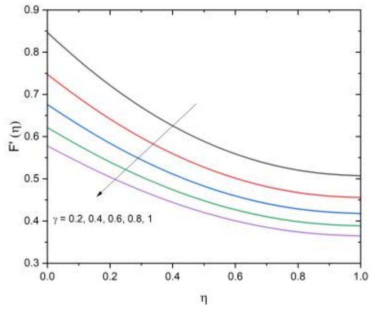

Figure 1: Effect of γ on $F'(\eta)$

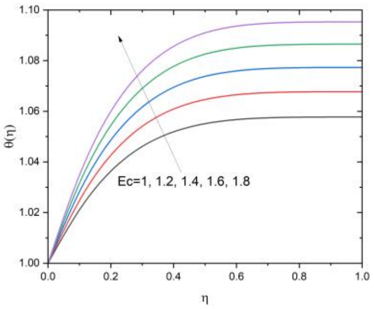

Figure 2: Effect of Ec on $\theta(\eta)$

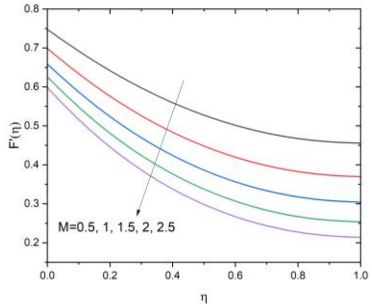

Figure 3: Effect of M on $F'(\eta)$

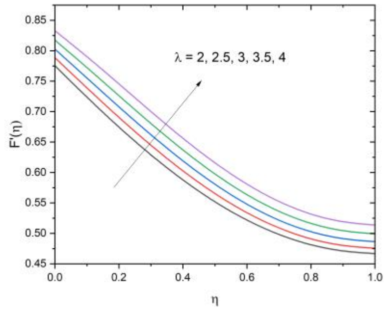

Figure 4: Effect of λ on $F'(\eta)$

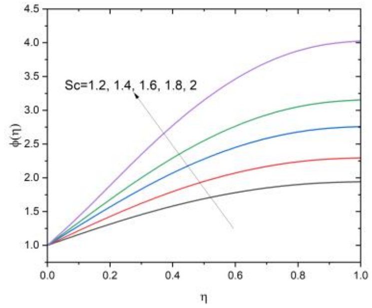

Figure 5: Effect of Sc on $\Phi(\eta)$

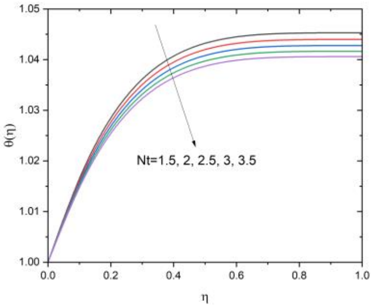

Figure 6: Effect of Nt on $\theta(\eta)$

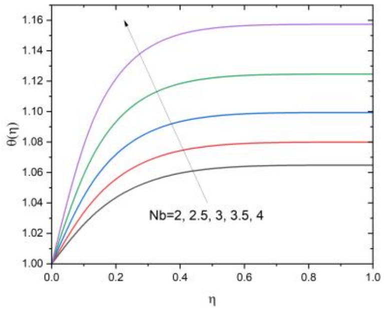

Figure 7: Effect of Nb on $\theta(\eta)$

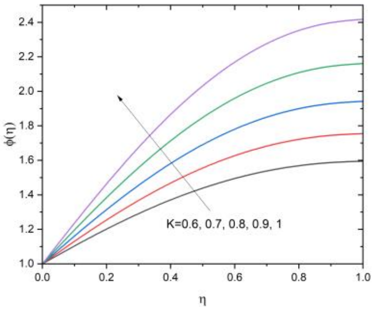

Figure 8: Effect of K on $\Phi(\eta)$

- The increase in the magnetic field parameter reduce the nanofluid flow velocity.
- The higher values of thermophoresis and Brownian motion significantly increased the temperature and concentration of the nanofluid.
- As the chemical reaction parameter was increased, it was observed that the concentration of the nanofluid decreased.
- The rise in the mixed convection parameter enhanced the nanofluid flow velocity.
- The increase in the Eckert number enhanced the internal heat generation that further contributed to the increase in the temperature of the nanofluid.

REFERENCES

1. H. Maiti and S. Mukhopadhyay, “Existence of MHD boundary layer hybrid nanofluid flow through a divergent channel with mass suction and injection,” *Chem. Eng. J. Adv.*, **14**, p. 100475, 2023.
2. V. Puneeth, M. I. Khan, M. Jameel, K. Geudri, and A. M. Galal, “The convective heat transfer analysis of the Casson nanofluid jet flow under the influence of the movement of gyrotactic microorganisms,” *J. Indian Chem. Soc*., **99**, no. 9, p. 100612, 2022.
3. R. Safdar, M. Jawad, S. Hussain, M. Imran, A. Akg¨ul, and W. Jamshed, “Thermal radiative mixed convection flow of MHD Maxwell nanofluid: implementation of Buongiorno’s model,” *Chinese J. Phys*., **77**, pp.1465–1478, 2022.
4. S. A. Lone, M. A. Alyami, A. Saeed, A. Dawar, P. Kumam, and W. Kumam, “MHD micropolar hybrid nanofluid flow over a flat surface subject to mixed convection and thermal radiation,” *Sci. Rep*., **12**, no. 1, p. 17283, 2022.
5. A. Felicita, B. J. Gireesha, B. Nagaraja, P. Venkatesh, and M. R. Krishnamurthy, “Mixed convective flow of Casson nanofluid in the microchannel with the effect of couple stresses: irreversibility analysis,” *Int. J. Modelling Simulation.*, **44**, no. 2, pp. 91–105, 2024.
6. S. Dey, S. Mukhopadhyay, and K. Vajravelu, “Effects of Stefan blowing on mixed convection heat transfer in a nanofluid flow with Thompson and Troian slip,” *Numer. Heat Transfer, Part A: Appl.*, pp. 1–20, 2023.
7. X. Xin, A. M. Saeed, F. A. M. Al-Yarimi, V. Puneeth, and S. S. Narayan, “The flow analysis of Williamson nanofluid considering the Thompson and Troian slip conditions at the boundary,” *Numer. Heat Transfer, Part A: Appl.*, **85**, no. 12, pp. 1937–1953, 2024.