Double Dispersion Effects in Graphene Oxide Nanofluid Convective Flow in an Inclined Channel

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1. ABSTRACT

This paper models and studies the flow of graphene oxide (GO) in an inclined channel including the impacts of double dispersion using Buongiorno nanofluid model. Spectral quasilinearization method with Chebyshev's polynomials is adapted to solve the differential equations under convective conditions. The effects of implanted parameters on velocity, temperature and concentration are graphed and interpreted.

Keywords: graphene nanofluids; entropy generation; Buongiorno model

2. INTRODUCTION

Graphene has the highest thermal conductivity of all the known materials[1]. For its advantageous thermophysical, mechanical and chemical properties, its immense use as coolants is raising aloft. The contribution to renewable energy, reassures economically large scale practical applications in view of power storage and capacity. Computational studies on graphene oxide (GO) nanofluids conclude that they aid in maximum heat transfer because of the excellent thermal conductivity. Some of the classical numerical studies on the fluid flow in inclined channels the study by Choi and Ortega[2] on the impacts of natural convective flow with a heat source placed in between two parallel plates. From the results, a strong dependence of the Nusselt number on the inclination angle is observed for values higher than $\pi/4$.

This paper computationally studies the flow of GO nanoparticles dispersed in water in inclined channel including the effects of double dispersion. The flow is modelled and the equations are numerically solved to graph the results.

3. GOVERNING EQUATIONS OF THE PROBLEM

The flow geometry is made up of two parallel plates aligned with an angle of inclination α. Water with dispersed GO nanoparticles flows steadily in the channel. We consider the body forces due to gravity, Brownian motion and thermophoresis effects and the effects caused by double dispersion. Thus, the problem is modelled adapting the Buongiorno nanofluid model[3] as follows:

$$\frac{\partial u}{\partial x}=0 \tag{2.1}$$

$$\rho_{nf}\left(v_0\frac{\partial u}{\partial y}\right)+\frac{\partial p}{\partial x}=\mu_{nf}\frac{\partial^2 u}{\partial y^2}+\left((\rho\beta)_{nf}(T-T_a)(1-C_a)-(\rho_{sp}-\rho_{bf})(C-C_a)\right)g\sin\alpha-\frac{\mu_{nf}}{\kappa}u-\sigma_{nf}B_0{}^2u \tag{2.2}$$

$$\tau D_B\left(\frac{\partial T}{\partial y}\right)\left(\frac{\partial C}{\partial y}\right)+\tau\frac{D_T}{T_a}\left(\frac{\partial T}{\partial y}\right)^2+\frac{\partial}{\partial y}\left(\alpha_e\frac{\partial T}{\partial y}\right)=0 \tag{2.3}$$

$$\frac{D_T}{T_a}\left(\frac{\partial^2 T}{\partial y^2}\right)+\frac{\partial}{\partial y}\left(D_e\frac{\partial C}{\partial y}\right)=0 \tag{2.4}$$

The corresponding convective no-slip boundary conditions are

$$\begin{aligned} &at\ y=-h, \quad u=0, \quad k_{nf}\frac{\partial T}{\partial y}=h_f\left(T-T_b\right), \quad D_m\frac{\partial C}{\partial y}=k_m\left(C-C_b\right) \\ &at\ y=h, \quad u=0, \quad k_{nf}\frac{\partial T}{\partial y}=h_f\left(T_a-T\right), \quad D_m\frac{\partial C}{\partial y}=k_m\left(C_a-C\right) \end{aligned} \tag{2.6}$$

4. METHODOLOGY

The governing equations and the corresponding boundary conditions are initially transformed to ordinary differential equations using a suitable transformation. Then the transformed ODEs along with the boundary conditions are solved using successive quasilinearization method (SQLM) adapted from Srinivasacharya and Hima Bindu.[4]

Additionally, Nusselt number, Sherwood number and skin friction values are tabulated, entropy genration analysis is conducted and the results are discussed.

5. CONCLUSION

Investigating the flow of water-based graphene oxide nanofluid in the geometry of inclined channel of the porous medium, we infer the following:

- Velocity can be enhanced by increasing the values of Reynolds number, suction/injection parameter, Hartmann number, and thermal Biot number.
- Heat transfer can be enhanced by enhancing thermal Biot number.
- Mass transfer can be enhanced by enhancing solutal dispersion paramter, suction/injection parameter, thermal and concentration Biot numbers and angle of inclination.

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