Duality solutions in hydromagnetic flow of SWCNT-MWCNT/water hybrid nanofluid over vertical moving slender needle

ABSTRACT

Recently, the topic of convection of heat transfer has created an interest among researchers because of its numerous applications in the daily life. The objective of this paper was to study theoretically the problem of mixed convection boundary layer flow and heat transfer of single-wall carbon nanotube (SWCNT) and multi-wall carbon nanotube (MWCNT) in presence of hydromagnetic effects. The problem was initiated by formulating a mathematical model in partial differential equation (PDE) for the hybrid nanofluid flow with appropriate boundary conditions. The similarity equation was used to transform the PDE into an ordinary differential equation (ODE) and solved using bvp4c in MATLAB. The graphical results on variation of skin friction coefficient, Cf, local Nusselt number, Nux, shear stress, $f''(c)$ and local heat flux, $-\theta'(c)$ with the effects of magnetic, M, size of needle, c, mixed convection parameter, λ and volume fraction of nanoparticles, φ were presented and discussed in detail. The study revealed that duality of solutions appears when the buoyance force is in opposing flow of the fluid motion, $\lambda<0$. The presence of M in hybrid nanofluid reduced the skin friction coefficient and heat transfer. On the other hand, the Cf and Nux increased as different concentrations of $\varphi 1$ and c were added. It gives an insight into the medical field, especially in treating cancer cells. By means, it reveals that CNTs hybrid nanofluid shows high potential in reaching the site of tumors faster compared with nanofluid. A stability analysis has to be carried out. It is noticed that the first solution was stable and physically realizable.

Keyword: Hybrid nanofluid; MHD; Mixed convection flow; Moving slender needle; Dual solutions