Magnetohydrodynamics flow past a moving vertical thin needle in a nanofluid with stability analysis

ABSTRCT

In this study, we intend to present the dynamics of a system based on the model of convective heat and mass transfer in magnetohydrodynamics (MHD) flow past a moving vertical thin needle in nanofluid. The problem is formulated in mathematical form by using Buongiorno's model with the modified boundary condition. The transformed boundary layer ordinary differential equations are solved numerically using the bvp4c function in MATLAB software. The effects of the involved parameters, including, Brownian motion, thermophoresis, magnetic field, mixed convection, needle size and velocity ratio parameter on the flow, heat and mass transfer coefficients are analyzed. The numerical results obtained for the skin friction coefficients, local Nusselt number and local Sherwood number, as well as the velocity, temperature and concentration profiles are graphically presented and have been discussed in detail. The study reveals that the dual solutions appear when the needle and the buoyancy forces oppose the direction of the fluid motion, and the range of the dual solutions existing depends largely on the needle size and magnetic parameter. The presence of the magnetic field in this model reduces the coefficient of the skin friction and heat transfer, while it increases the coefficient of the mass transfer on the needle surface. A stability analysis has been performed to identify which of the solutions obtained are linearly stable and physically relevant. It is noticed that the upper branch solutions are stable, while the lower branch solutions are not.

Keyword: Stability analysis; Dual solutions; MHD; Mixed convection; Thin needle; Nanofluid.