

Flow and heat transfer of hybrid nanofluid over a permeable shrinking cylinder with Joule heating: a comparative analysis

ABSTRACT

The objectives of the present study are (i) to observe the duality of solutions, and (ii) to investigate the flow and heat transfer of the hybrid nanofluid past a shrinking cylinder in the appearance of Joule heating. The single phase nanofluid model with modified thermophysical properties are used for the mathematical model. The similarity transformation simplifies the model (PDEs) into similarity (ordinary) differential equations. bvp4c solver is used to compute the reduced equations. For the validation part, the analytical solution is developed using an exact analytical method and compared with the numerical values for several cases. First and second solutions are observable for the shrinking cylinder case only if suction parameter is applied. Meanwhile, only the first solution is found to be stable from the stability analysis. The application of high suction strength make the reduced heat transfer rate is lower for hybrid nanofluid (Cu-Al₂O₃/water) than alumina-water nanofluid but, opposite result is found for the skin friction coefficient. The addition of curvature parameter (flat plate to cylinder) can quicken the separation process of boundary layer. This results are conclusive to the pair of alumina and copper only.

Keyword: Hybrid nanofluid; Heat transfer; Shrinking cylinder; Suction; Joule heating; Dual solutions