Heat transfer and Entropy Analysis of Forced Convective Nanofluid Boundary Layer Flow upon a Wedge with Thermal Radiation

Abstract

Purpose : In heat transfer, fluids and nanoparticles can provide new innovative technologies with potential to adapt the heat transfer fluids thermal properties through control over particle type, size, shape and others. This paper aims to examine the effects of single and multi-walled CNTs nanoparticles on heat transfer enhancement and inherent irreversibility in boundary layer of water base nanoliquid flow over a convectively heated moving wedge with thermal radiation.

Design/methodology/approach : Wedge angle manipulation provides the chance of comparing physical aspect in the flow states, where three main geometries of the well-known Falkner-Skan problem including: i) the flat plat (named Blasius flow), ii) the wedge, and iii) the vertical plate (named Hiemenz stagnation flow) have been considered to present a comprehensive development of this significant problem. Applying suitable similarity constraints, the model partial differential equations are transformed into a set of nonlinear ordinary differential equations. Solutions are obtained analytically via optimal homotopy asymptotic method (OHAM) and numerically via shooting technique coupled with the Runge-Kutta-Fehlberg 4-5th scheme (RKF-45).

Findings : The impact of solid volume fraction of carbon nanoparticles along with other germane factors, such as wedge angle, velocity ratio parameter, Biot number, thermal radiation, etc… on velocity and thermal profiles, Nusselt number, skin friction coefficient, heat transfer enhancement, rate of entropy generation and irreversibility ratio, are scrutinized via graphical simulations and discussed. Optimization of such entropy developments in the system were found to be depends on geometrical (β), dynamical (λ) and thermophysical (Bi, N_R, Ec, φ) parameters. The ultimate objective of reducing the energy loss and enhanced heat transference were obtained with the geometrical manipulation for flat plate cases. Dynamically (λ=1) were spotted to exerts best fluidity irrespective of obstacle shapes (wedge of plate) in it way. In thermophysical aspects reducing the convective heating develops the favourable situation for attaining the optimal balance between energy loss and heat transfer. SWCNT/water could be the better choice with enhanced thermal transference ability and exerts minimal irreversibility to over shade the influences of all the above mentioned factors. The SWCNT suspended nanofluid can provide 12% to 64% heat transfer enhancement when comparing to the MWCNT nanofluid which ranges over 11% to 58% heat transference rate. Irreversible energy loss from the system were spotted with the contributing factors and also found the optimal fluid choice to exert it factors like fluid friction, convectional heating, radiation heat were tends to elevates the entropy formations.

Originality/value : The main objective of this work is to examine the different effects of different physical parameters on the heat transfer enhancement and inherent irreversibility owing to nanoliquid flow past a convectively heated wedge, and to try to reach the best state of the flow which has not been yet studied. It is hope that this study will bridge the gap in the present literature and serve as impetus to scholars, engineers and industries for more exploration in this direction.

Keywords : Carbon NTs ; Boundary layer flow ; Irreversibility ; Entropy generation ; OHAM ; RKF-45.