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Vemula, R., Chamkha, A., Mallesh, M.P.

Nanofluid flow past an impulsively started vertical plate with variable surface temperature
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Abstract
Purpose - The purpose of this paper is to focus on the numerical modelling of transient natural convection flow of an incompressible viscous nanofluid past an impulsively started semi-infinite vertical plate with variable surface temperature. Design/methodology/approach - The problem is governed by the coupled non-linear partial differential equations with appropriate boundary conditions. A robust, well-tested, Crank-Nicolson type of implicit finite-difference method, which is unconditionally stable and convergent, is used to solve the governing non-linear set of partial differential equations. Findings - The local and average values of the skin-friction coefficient (viscous drag) and the average Nusselt number (the rate of heat transfer) decreased, while the local Nusselt number increased for all nanofluids, namely, aluminium oxide-water, copper-water, titanium oxide-water and silver-water with an increase in the temperature exponent m. Selecting aluminium oxide as the dispersing nanoparticles leads to the maximum average Nusselt number (the rate of heat transfer), while choosing silver as the dispersing nanoparticles leads to the minimum local Nusselt number compared to the other nanofluids for all values of the temperature exponent m. Also, choosing silver as the dispersing nanoparticles leads to the minimum skin-friction coefficient (viscous drag), while selecting aluminium oxide as the dispersing nanoparticles leads to the maximum skin-friction coefficient (viscous drag) for all values of the temperature exponent m. Research limitations/implications - The Brinkman model for dynamic viscosity and Maxwell-Garnett model for thermal conductivity are employed. The governing boundary layer equations are written according to The Tiwari-Das nanofluid model. A range of nanofluids containing nanoparticles of aluminium oxide, copper, titanium oxide and silver with nanoparticle volume fraction range less than or equal to 0.04 are considered. Practical implications - The present simulations are relevant to nanomaterials thermal flow processing in the chemical engineering and metallurgy industries. This study also provides an important benchmark for further simulations of nanofluid dynamic transport phenomena of relevance to materials processing, with alternative computational algorithms (e.g. finite element methods). Originality/value - This paper is relatively original and illustrates the influence of variable surface temperature on transient natural convection flow of a viscous incompressible nanofluid and heat transfer from an impulsively started semi-infinite vertical plate. © Emerald Group Publishing Limited.

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