MHD Flow of Casson Hybrid Nanofluid with Heat Transfer Enhancement: Numerical Insights of Fractal-Fractional modelling

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Abstract

Fractional calculus expands the idea of differentiation to fractional/non-integer orders of the derivatives. It includes the memory-dependent and non-local system's behaviors while fractal-fractional derivatives is the generalization of fractional order derivatives which refers to a combination of fractional calculus and fractal geometry. In this article, we have considered the MHD flow of Casson hybrid nanofluid through a vertical open channel with the effect of viscous dissipation and Newtonian heating. The problem is modelled in terms of non-linear and coupled integer order PDEs which is further generalized through fractal-fractional derivative of power law kernel. Due to non-linearity and complexities, we have adopted the numerical procedure as it is used when the analytical solutions of PDEs are frequently difficult or impossible for complicated situations. We have established the numerical algorithms for both the classical as well as fractal-fractional order model and compared the results. The existence and uniqueness of the model's solution has been shown theoretically. The effect of various embedded parameters on the heat transfer and fluid flow have been simulated and presented through various figures while skin friction and nusselt number are tabulated. The effect of fractional and fractal parameter is also shown. As, the present model is taken for the hybrid nanofluid flow and for the heat transfer applications, we have considered mineral transformer oil as a base fluid while Titania and cadmium tiluride nanoparticles are dispersed in it. From the results, it is observed that hybrid nanofluid have a better heat transfer enhancement up to 19.71% while the unitary nanofluids are only capable to enhance the heat transfer up to 9%.

Keywords: Casson fluid; Hybrid nanofluid; Viscous dissipation; Newtonian heating; Numerical algorithms; Fractal-fractional derivative.

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