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Mixed convection of MHD Reiner–Philippoff fluid flow past a vertical shrinking plate with radiative heat transfer

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ABSTRACT

The mixed convection and radiative flow with thermal characteristics of a non-Newtonian Reiner–Philippoff fluid towards a permeable vertical plate are analysed in this study. This unique model is designed to observe both shear thickening and shear thinning behaviours in that particular fluid. The governing equations are constructed using the theoretical assumptions and then reduced to a set of ordinary differential equations (ODEs). The steady flow solutions are computed using the Matlab software bvp4c. Dual solutions are observed and their physical significance is justified using the temporal stability analysis. The thermal development of this fluid is aided by the employment of the magnetic field and suction effect. However, the high magnitude of the radiation parameter leads to the deterioration in the thermal rate. From the standpoint of the Reiner–Philippoff fluid parameter, the skin friction coefficient and heat transfer rate are at maximum for the shear-thickening fluid followed by the Newtonian and shear-thinning fluids, respectively.

1. Introduction

Nowadays, industrial and technological applications demand effective working fluid in determining the optimum production. Conventionally, pure water (Newtonian) as a cooling agent is used in many processes but the use of the non-Newtonian type of fluid becoming more relevant due to its effectiveness and applicability. There are many types of non-Newtonian fluids available that present a special feature in their properties. Different from the Newtonian type fluid whose strain is in line with stress tensor, the non-Newtonian types are classified by the behaviour of either shear-thinning which present pseudo-plasticity or shear thickening describing the dilatant. The shear-thickening fluid indicates the growth in viscosity proportional to the shear rate whereas the shear-thinning displays the Newtonian fluid's behaviour in extreme values of shear rate. Models fluid convey the shear thickening and thinning behaviors have been mentioned in Deshpande et al. [1] including the model of Reiner–Philippoff, Sisko, Powell–Eyring, Carreau–Yasuda as well as Carreau viscosity. Additionally, to give a broader view of the literature on the other non-Newtonian fluids, one can refer to Refs. [2–7]. Among the model under the non-Newtonian group, the Reiner–Philippoff is more interesting to investigate

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