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Multifarious slips perception on unsteady Casson nanofluid flow impinging on a stretching cylinder in the presence of solar radiation

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Abstract. In the present work, a study is prepared for unsteady axisymmetric Casson-type nanofluid flow as a result of a contracting impermeable cylinder under the influence of solar radiation. The model of multifarious slip is included. The governing system of equations takes the form of non-linear ODEs by employing appropriate transformation and then resolve it numerically by RK-Fehlberg scheme in Maple 18 symbolic software. The effects of leading parameters on the flow characteristics are presented through tables and graphs coupled with necessary discussion and physical insinuation. Strong effects of various slip parameters on the physical quantities of interest are found here. The upsurge of surface slip is spotted to boost up temperature profile whereas it slows the flow down. However, thermal slip conducts to drop the temperature but enhancing the heat transfer rate.

1 Introduction

Most of the inorganic salts (low molecular weight), organic/inorganic liquids display Newtonian flow features, *i.e.* the shear stress and shear rate are proportional to each other. Classically, such fluids are recognized as the Newtonian fluids. But, if we go back to the past six decades we can see that scientists have accepted the fact that many fluids of multi-phase nature (slurries, foams), man-made or natural polymeric solutions and melts do not adapt Newtonian flow characteristics. For such fluids, the association between shear stress and rate of shear are not linear. All such fluids are called non-Newtonian fluids. Casson fluids are visco-plastic fluids, whose activities are distinguished by the subsistence of a threshold stress, called yield stress, which must be surpassed for such fluids to flow. Thus such a substance will act as a rigid body when the external stress is smaller than the yield stress. Certainly, the Casson fluid reveals shear-thinning characteristics once the magnitude of the external stress goes beyond the value of yield stress. Blood, tomato sauce/puree, chocolate, cosmetics, foams, etc., are typical models of Casson fluid. As the areas of application of a Casson fluid are exceptionally broad in industrial, biomedical and biological settings, scientists, mathematicians, engineers with different cultural background put their dominant interest to the flow of Casson nanofluid. Nadeem *et al.* [1] investigated Casson fluid flow for the 3D case. Khalid *et al.* [2] extended this study for free convective flow. A numerical approach for MHD flow over an oscillating porous sheet for Casson fluid was scrutinized by Gireesha *et al.* [3]. Khalid *et al.* [4] analyzed the case of unsteady free convection on such fluid over a plane with fixed temperature. Animasaun [5] explored the thermophoretic and Dufour effects on electrically conducting incompressible Casson fluid. Similar investigations can be found in [6–10].

At present, scientists around the world are busy to find the resources of sustainable and renewable energy as usage of the other source of energy (*e.g.* fossil fuel). To obtain the global energy requirement became a serious issue. Solar energy is the most eligible candidate in this path, for the energy produced from it is enough for millions of years with minimal environmental impact. It is the solar power from which we get heat or electricity in a natural way. Study through solar radiation has achieved special focus by several researchers [11–15]. A constructive model for solar radiation was build up by Shehzad *et al.* [16]. In this model, they appraised a nanofluid with laminar flow towards a thermally radiative moving surface. Recently, Acharya *et al.* [17] maintained the flow of a nanofluid past a permeable

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