Stagnation point flow of a second-grade hybrid nanofluid induced by a Riga plate

Najiyah Safwa Khashi'ie and Iskandar Waini
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia

Syazwani Mohd Zokri
Fakulti Sains Komputer dan Matematik, Universiti Teknologi MARA, Kuala Terengganu, Malaysia

Abdul Rahman Mohd Kasim
Pusat Sains Matematik, Universiti Malaysia Pahang, Gambang, Malaysia

Norihan Md Arifin
Department of Mathematics, Faculty of Science, Universiti Putra Malaysia, Seri Kembangan, Malaysia, and

Ioan Pop
Department of Mathematics, Babes Bolyai University, Cluj Napoca, Romania

ABSTRACT
Purpose: This paper aims to accentuate the behavior of second-grade hybrid Al_2O_3–Cu nanofluid flow and its thermal characteristics driven by a stretching/shrinking Riga plate. **Design/methodology/approach**: The second-grade fluid is considered with the combination of Cu and Al_2O_3 nanoparticles. Three base fluids namely water, ethylene glycol (EG) and methanol with different Prandtl number are also examined. The formulation of the mathematical model of second-grade hybrid nanofluid complies with the boundary layer approximations. The complexity of the governing model is reduced into a simpler differential equations using the similarity transformation. The bvp4c solver is fully used to solve the reduced equations. The observation of multiple solutions is conducted for the assisting (stretching) and opposing (shrinking) cases. **Findings:** The impact of suction parameter, second-grade parameter, electromagnetohydrodynamics (EMHD) parameter, velocity ratio parameter and the volumetric concentration of the alumina and copper nanoparticles are numerically analyzed on the velocity and temperature profiles, skin friction coefficient and local Nusselt number (thermal rate) of the second-grade Al_2O_3–Cu/water. The solution is unique when (static and stretching cases) while dual for a specific range of negative in the presence of suction effect. Based on the appearance of the first solution in all cases of, it is physically showed that the first solution is stable. Further examination reveals that the EMHD and suction parameters are the contributing factors for the thermal enhancement of this non-Newtonian working fluid. Meanwhile, the viscosity of the non-Newtonian fluid also plays a significant role in the fluid motion and heat transfer rate based on the finding that the EG

base fluid produces the maximum heat transfer rate but the lowest critical value and skin friction coefficient. **Originality/value:** The results are novel and contribute to the discovery of the hybrid nanoparticles' performance in the non-Newtonian second-grade fluid. Besides, this study is beneficial to the researchers in this field and general audience from industries regarding the factors, which contributing to the thermal enhancement of the working fluid.

KEYWORDS
Heat transfer; Hybrid nanofluid; Riga plate; Second-grade; Stagnation point flow

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