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RSM and fcontour analyzation on convective heat transfer in hybrid nanofluids with radiation absorption, Brownian motion, and Biot number

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Abstract
A number of thermal systems are employing hybrid nanofluids to cool their devices, particularly in scorching environments, and these technologies are embraced across a wide range of thermal systems, including electronic device cooling, heat exchangers, manufacturing and automotive sectors, heat pipes, and solar energy systems. In the current investigation, the flow of MHD HNF(Ag–CuO/H_2O) across an expanding surface is studied in 3D rotation. As part of this study, activation energy and viscous dissipation effects are incorporated into the equations that govern the system. Mathematics is used to formulate coupled nonlinear PDEs that are then transformed into ODEs through similarity transformations. The bvp4c method is then applied to the resulting system with the shooting technique. Based on graphical illustrations, the results of this study provide a detailed analysis of the effects of various parameters on flow profiles for hybrid nanofluids. In addition, key physical parameters are quantified using Response Surface Methodology (RSM). A numerical solution for RSM and fcontour plots is typically generated using MATLAB's bvp4c followed by an analysis based on RSM. A number of engineering and biomedical applications can be developed using this work, including the design of efficient bioreactors, the development of microbial fuel cells, precision drug delivery, advanced biomedical cooling devices, and the use of bio-nanofluids for wastewater treatment. As well, the study provides theoretical groundwork that can be applied to bio-inspired nanotechnology, optimized microfluidic thermal systems, and energy-efficient biomedical transport. Hybrid Ag–CuO/water nanofluids have excellent thermal performance, providing a significant increase in both convective heat transfer and thermal conductivity. They are often used in microchannel heat sinks and stretching sheet thermal models. The results of using Ag–CuO/water show an improvement in heat transfer of up to 30.49% and improved friction coefficients.

Keywords RSM · Ag–CuO/H_2O · Convective constraints · Heat transfer · Stretching surface

List of Symbols

x, y, z	Distance in three-dimensional space
B_o	Magnetic field strength
C_p	Heat capacity
k	Thermal conductivity
ρ	Density
Ω	Surface angular velocity
ν	Kinematic viscosity
Nb	Brownian parameter
T_f	Surface temperature
hnf	Hybrid nanofluid
Sc	Schmidt number
R	Radiation parameter
Fr	Forchheimer number
Bi_T	Thermal Biot number
Q	Heat source parameter
u, v, w	Velocity components in the x, y, z directions

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