68th Congress of the Indian Society of Theoretical and Applied Mechanics (ISTAM) (An International Conference), December 07-09, 2023

Simulation of temperature-dependent viscosity on unsteady flow of hybrid nanofluid over porous stretching sheet using Legendre wavelet collocation technique

Tanya Gupta* and Manoj Kumar

Department of Mathematics, Statistics and Computer Science, G.B. Pant University of Agriculture and Technology, Pantnagar, India
Email address: (Corresponding author), mnj_kumar2004@gmail.com

Abstract

The article uses the Legendre wavelet collocation technique to present the numerical solution of magnetized GP-$MoS_2/C_2H_6O_2$-H_2O hybrid nanofluid unsteady flow over a stretching surface. Here, we incorporated Legendre wavelet basis functions and its operational matrix of integration, which gives precise solutions for non-linear ODEs. The results declare that the heat transfer rate of GP-$MoS_2/C_2H_6O_2$-H_2O is continuously augmented with the rise in temperature-dependent viscosity (TDV). At the same time, the velocity outlines of working hybrid nanofluid constantly reduced with an increase in TDV. The suction diminishes the velocity and temperature profiles.

1. Introduction

The flow analysis on stretching sheet has a major role in engineering and technology. Studies on stretching sheet include extrusion of sheet material. The investigation of boundary layer flow over moving surfaces was first done by Sakiadis [1] in 1961.

Wavelets originated solely by mathematicians, electrical engineers, quantum physicists, and geologists, but alliances between these domains have resulted in new diverse uses. These are adopted to solve fluid dynamics flow governing equations, called the Legendre wavelet collocation technique (LWCT) [2]. It is a relatively new technique in the field of fluid dynamics.

On viewing the previous literature, a mathematical model is created to find the numerical solution of unsteady flow of magnetic hybrid nanofluid (GP-$MoS_2/C_2H_6O_2$-H_2O) over a stretching surface with suction and viscous dissipation by using Legendre Wavelet Collocation Technique (LWCT). Graphs examine the influence of temperature-dependent viscosity and suction on temperature and velocity.

2. Formulation of the problem [3]:

$$U_x + V_y = 0, \tag{1}$$

$$U_t + UU_x + VU_y = \frac{1}{\rho_{hnf}}\frac{\partial}{\partial y}\left(\mu_{hnf}U_y\right) - \frac{\sigma_{hnf}}{\rho_{hnf}}B_0^{\,2}U\sin^2\gamma - \frac{\mu_{hnf}U}{\rho_{hnf}k_p^*}, \tag{2}$$

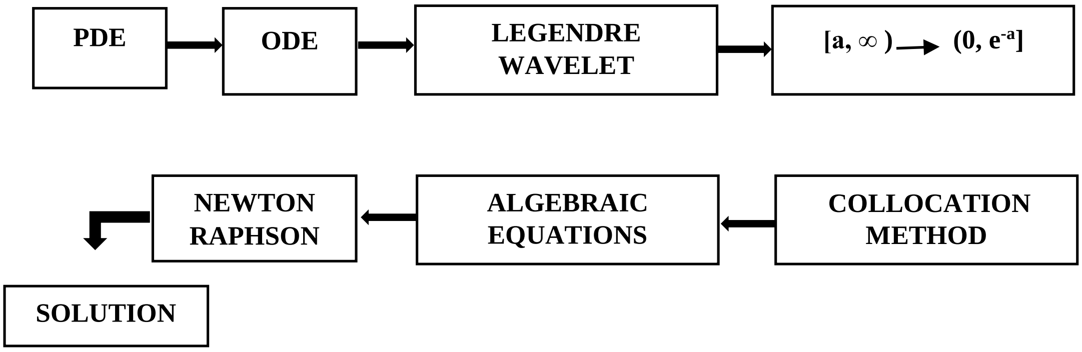
$$\left(\rho C_p\right)_{hnf}\left(T_t + UT_x + VT_y\right) = k_{hnf}T_{yy} + \mu_{hnf}U_y^2 + \sigma_{hnf}B_0^{\,2}U^2\sin^2\gamma + \frac{\mu_{hnf}U^2}{k_p^*}. \tag{3}$$

$$\text{Boundary condition: } \left.\begin{array}{ll} t \le 0 \; : U = 0,\; V = 0, T = T_\infty, & y \ge 0, \\ t > 0 \; : U = U_w, V = V_w, T = T_w, & y = 0, \\ \quad U \to 0, T \to T_\infty, & y \to \infty. \end{array}\right\} \tag{4}$$

Space and time-dependent variables: $B_0 = \frac{B_1}{\sqrt{1-c_1 t}} x^{\frac{n-1}{2}}, k_p^* = k_1 \frac{1-c_1 t}{x^{n-1}}, T_w = T_\infty + \frac{T_r}{(1-c_1 t)^2}\left(\frac{x}{L}\right)^{2n}$

Temperature-dependent viscosity: $\mu_{bf} = \frac{\mu_\infty}{1+\omega\left(T-T_\infty\right)}$ (5)

3. Solution Methodology



4. Findings and conclusions

- The heat transfer performance of GP-$MoS_2/C_2H_6O_2$-H_2O escalated with TDV values.
- Velocity profiles of GP-$MoS_2/C_2H_6O_2$-H_2O decelerated with TDV.
- With increasing suction parameter velocity profiles depreciated.
- Increasing the values of suction, temperature outlines are constantly declined.

References

1. B. C. Sakiadis, "Boundary-layer behavior on continuous solid surfaces: II. The boundary layer on a continuous flat surface" *AIChE Journal*, *7*(2), 221-225, 1961.

2. M. Razzaghi, and S. Yousefi, "The Legendre wavelets operational matrix of integration" *International Journal of Systems Science*, *32*(4), 495-502, 2001.

3. I. Waini, A. Ishak, and I. Pop "Hybrid nanofluid flow towards a stagnation point on a stretching/shrinking cylinder" *Scientific Reports*, *10*(1), 1-12, 2020.

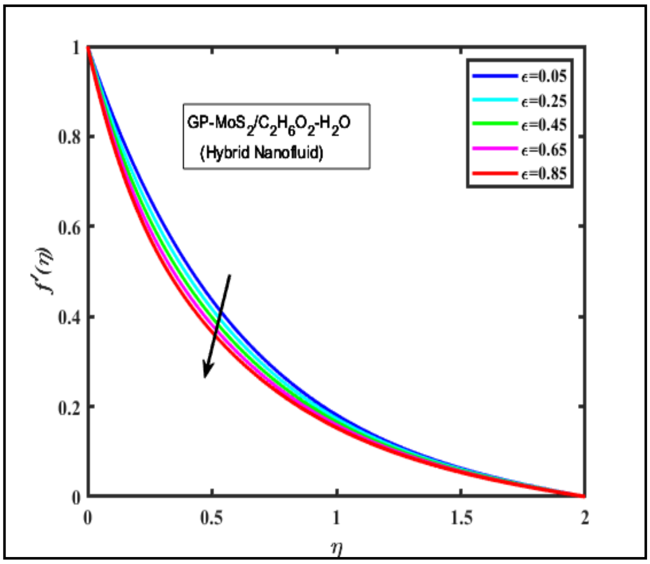


Fig 1. Velocity profile for temperature-dependent viscosity.

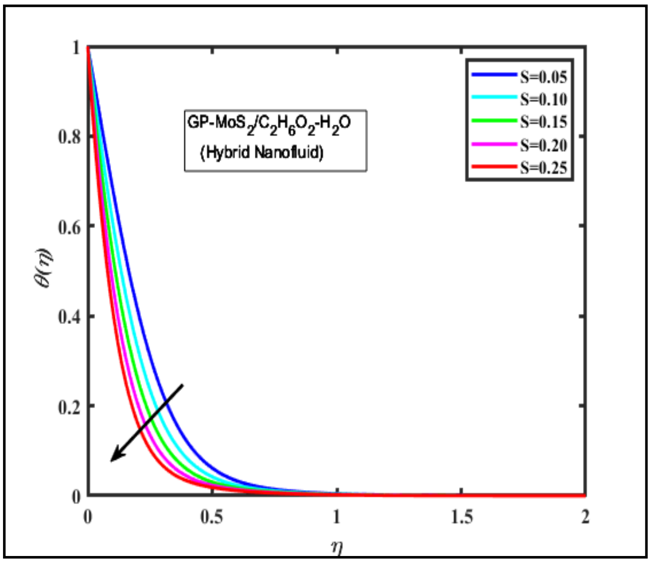


Fig 2. Velocity profile for suction parameter.