A numerical study of two-phase nanofluid MHD boundary layer flow with heat absorption or generation and chemical reaction over an exponentially stretching sheet by Haar wavelet method

Kumbinarasaiah S

Department of Mathematics, Bangalore University, Bengaluru, India

1. INTRODUCTION & OBJECTIVE

The study of boundary layer flows, and heat transfer due to nonlinear or exponentially stretching surfaces has become more and more important in many industrial applications. Due to this, we considered the two-phase nanofluid MHD boundary layer flow model with heat absorption or generation and chemical reaction via porous media due to an exponential stretching sheet. Here, we considered a novel technique called the Haar wavelet collocation method (HWCM) to study the considered model. First, the governing nonlinear partial differential equations (PDEs) are transformed into coupled, highly nonlinear, ordinary differential equations (ODEs) using similarity transformations. Then the coupled ODEs are translated from the infinite domain [0, ∞) to the finite domain [0, 1] via coordinate transformation because the wavelet plays a crucial role in [0, 1]. The obtained equations are converted into nonlinear algebraic equations using HWCM. HWCM solution will be obtained by treating the above nonlinear algebraic equations through the Newton-Raphson method. The obtained results are compared with other methods in the literature to justify the HWCM. The impacts of the physical parameters are discussed using tables and graphs. It was found that the Nusselt number $Re_x^{-1/2}\, Nu_x$ is a decreasing function of the magnetic field, porous media parameter, heat generation or absorption parameter, and chemical reaction parameter.

Table 1. Fonts sizes to be used for various types of text. All fonts are Times New Roman or an equivalent. Table captions should be centered above the table. Figure captions should be centered below the figure or graph. When the caption is too long to fit on one line, it should be justified to the right and left margins of the body of the text.

Article title	**A numerical study of two-phase nanofluid**

	MHD boundary layer flow with heat absorption or generation and chemical reaction over an exponentially stretching sheet by Haar wavelet method
Author names	Kumbinarasaiah S
Affiliations and address	Department of Mathematics, Bangalore University, Bengaluru, India
Section heading	**FLUID MECHANICS**
Subsection heading	**FM7**
Sub-subsection heading	***Computational Fulid Dynamics***

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

In this study, we have used the HWCM to study the effect of some physical parameters on the MHD nanofluid boundary layer flow through a porous media due to an exponentially stretching sheet in the presence of heat generation or absorption and chemical reaction. The governing PDEs are transformed into highly nonlinear coupled ODEs using suitable similarity transformations. Obtained coupled ODEs are defined on $[0, \infty)$, but wavelets play an essential role in the limited domain [0,1]. So, we transformed this system of ODEs from a semi-infinite domain $[0, \infty)$ to a finite domain [0,1]. The resulting equations are numerically solved using HWCM. The accuracy of HWCM is validated with previously available numerical results. The important observations from this article are:

- The momentum boundary layer thickness increases by increasing the parameters $\lambda_T, V_r, Ec, N_b, N_t,$ and Q and reduces by the parameters $Pr, \kappa, M,$ and Q.
- The parameters $V_r, Ec, N_b, N_t, \kappa, M,$ and Q enhance the thickness of the thermal boundary layers and the parameters λ_T, Le and Pr reduce the thermal boundary layer thickness.
- Solutal boundary layer thickness increases with increasing $V_r, \kappa,$ and M and decreases as the parameters $Pr, N_b, N_t, Le, Q,$ and χ increase.
- The skin friction coefficient is an increasing function of $M, \kappa,$ and χ, whereas it is a decreasing function of Q.
- The Nusselt number is a decreasing function of $M, \kappa, Q,$ and χ.
- The Sherwood number is an increasing function of Q and χ while decreasing function of M and κ.

REFERENCES

1. L.J. Crane, *Flow past a stretching plate*, ZAMP, 21, pp. 645–647, 1970.

2. B. Bidin and R. Nazar, “Numerical solution of the boundary layer flow over an exponentially stretching sheet with thermal radiation.,” Eur. J. Sci. Res., 33(4), pp. 1450-216, 2009.

3. I.L. Animasaun, E.A. Adebile, and A.I. Fagbade, “Casson fluid flow with variable thermo-physical property along exponentially stretching sheet with suction and exponentially decaying internal heat generation using the homotopy analysis method,” J. Nigerian Math. Soc, 35(1), pp. 1-17, 2016.

4. N.N. Reddy, V.S. Rao, and B.R. Reddy, “Chemical reaction impact on MHD natural convection flow through porous medium past an exponentially stretching sheet in presence of heat source/sink and viscous dissipation,” Case Stud. Therm. Eng., 25, pp. 100879, 2021.

5. T. Hayat, M. Ijaz Khan, M. Waqas, A. Alsaedi, and T. Yasmeen, “Diffusion of chemically reactive species in third grade fluid flow over an exponentially stretching sheet considering magnetic field effects,” Chin. J. Chem. Eng., 25(3), pp. 257-263, 2017.