A Method of Optimal Homotopy Analysis for Solutions of Boundary Layer Convection Heat Transfer of High-Speed Flow Over a Flat Plate

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The present study addresses the intricate problem of boundary layer convection heat transfer in high-speed flow over a flat plate. The governing continuity and Navier-Stokes equations are considered under boundary layer assumptions and constant property assumptions. By introducing dimensionless variables, the equations are transformed into a coupled system, facilitating analysis. The goal of the research is to employ the Basic Optimal Homotopy Analysis Method (OHAM) to solve these equations and analyze heat transfer characteristics. OHAM, rooted in topology and geometry concepts, constructs linear operators, initial approximations, and deformation equations. The introduced parameter $\hbar$ is optimized using step-by-step optimization to minimize residual error, yielding accurate solutions satisfying initial and boundary conditions. Results demonstrate the accuracy of the approach, yielding higher-order approximations with minimal errors. Employing this approach, a 10th-order approximate solution is obtained, where errors are confined to third-order approximations. The presented results are consistent with the Mathematica package BVPH 2.0 developed by Liao. The presented figures illustrate velocity and temperature profiles, while a comparative table showcases the effectiveness of the method under different parameter sets. This study contributes to understanding complex convection heat transfer phenomena in high-speed flow scenarios. The proposed OHAM offers exceptional accuracy, making it a powerful tool for solving nonlinear systems in various fluid dynamics problems. The approach can be effectively employed for solving boundary layer convection heat transfer problems in high-speed flow.

Keywords: Optimal homotopy analysis method (OHAM), Boundary layer, Convection heat transfer, High-speed flow, Flat plate