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RESEARCH PAPER

Fourier-homotopy perturbation method for heat and mass transfer with 2D unsteady squeezing viscous flow problem

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Abstract

In this article, the homotopy perturbation method (HPM) and Fourier transform (FT) were combined to construct a hybrid method that can be represented by the symbol (FT-HPM), the new technique succeeded to find an approximate solution for the model of heat and mass transfer in the unsteady squeezing flow between parallel plates analytically. The similarity transformation methodology was relied upon to convert a system of partial differential equations into a system of ordinary differential equations. The influence of physical parameters (squeeze number, Prandtl number, Schmidt number and the Eckert number) on velocity, temperature and concentration with different values is discussed. In addition, the physical quantities represented by the Nusselt number, Sherwood number, and the skin friction coefficient were studied, and the new numerical results of these quantities were compared with the results of previously published works. Finally, the convergence of the new method was studied theoretically by formulating the basic convergence theorem. In addition, this theorem was applied to the results of the solutions obtained using FT-HPM. The tables and graphs of the new analytical solutions showed the possibility and usefulness of using the new algorithm to deal with many non-linear problems, especially natural convection problems.

Keywords: Homotopy perturbation method, Fourier transform, Heat and mass transfer, Unsteady squeezing flow, convergence analysis.

1. Introduction

For decades, scientists and engineers have been interested in studying the theory of viscous flow, especially the flow of Newtonian and non-Newtonian fluids, because of its wide applications in various branches of science and technology. Many of these applications can be described by ordinary or partial nonlinear differential equations. In recent years, many powerful methods have been developed to obtain approximate solutions of nonlinear differential equations. The problem of heat and mass transfer combined with unsteady two-dimensional squeezing viscous flow have received the attention of many authors because there are many scientific and engineering applications for this problem, such as food processing, cooling towers, drying, chemical processing equipment, and surface evaporation. and polymer processing, hydrodynamic machines, etc. The researchers succeeded in presenting many theoretical and experimental studies on the mentioned problem. Let's take an example, Mahmood et al. [1] used the perturbation method, asymptotic method and the local non-similarity method to solve the problem of flow and heat transfer over a permeable sensor surface placed in a squeezing channel. This study illustrated that the solutions of local non-similarity agree with the solutions of perturbation for large and small values of the local transpiration parameter. The 2D unsteady flow with heat and mass transfer of viscous fluid between the infinite parallel plates was solved by Mustafa et al. [2], relying on similarity transformation and the homotopy analysis method (HAM), the study showed that only the tenth-order of approximation leads to convergent solutions. Sheikholeslami [3] applied the Adomian decomposition method (ADM) to simulate the model of unsteady squeezing nanofluid flow and heat transfer. And also, Sheikholeslami et al. [4] used the homotopy perturbation method (HPM) to analyze the problem of two phase

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