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Chebyshev-Homotopy Perturbation Method for Studying the Flow and Heat Transfer of a Non-Newtonian Fluid Flow on the Turbine Disk

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A B S T R A C T

In this investigation, a new method for studying the effect of non-Newtonian fluid on the flow and temperature distribution when cooling the turbine disk is presented. The new method is based on the homotopy perturbation method developed with the Chebyshev series. The results of the proposed method were compared with the results obtained using numerical methods in previous literature to ensure the validity of the method, as it showed good agreement. The effect of several physical parameters on flow velocity and temperature diffusion, such as the Reynolds number, cross viscosity parameter, Prandtl number, and power law, was explored. The results obtained using the proposed method were more accurate than other methods used to solve the current problem. Moreover, figures and error tables show the new method's efficacy and efficiency.

1. Introduction

The application of non-Newtonian fluids is an important and widespread issue. One of the most important of these applications is the flow of non-Newtonian viscous elastic fluid in an isoaxial channel with a porous wall. Because the goal of the application is to reduce the heat generated on the turbine disk, researchers paid great attention to it. As an example, Dogonchi and Ganji [1] used a novel technique depending on the Duan-Rach methodology in order to solve the problem of turbine cooling application. Sepasgozar et al. [2] studied non-Newtonian fluid flow in a porous channel using the differential transformation method (DTM). Their findings supported the efficacy of their methodology, with comparisons to numerical approaches demonstrating high agreement. Mirgolbabaee and colleagues [3] presented Akbari-Ganji's approach for determining the approximate solutions of the nonlinear equations that describe the flow of a non-Newtonian fluid to the problem of turbine cooling. A comparative evaluation with the fourth-order Runge-Kutta technique revealed a strong agreement in their results. Singh and Yadav [4] employed the perturbation method to findthe approximate solution to the heat transfer and momentum equations of the non-Newtonian fluid flow.

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