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Network modeling to study the unsteady unidirectional flows of a non-Newtonian fluid problem

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ABSTRACT

The unsteady unidirectional flow problem of a non-Newtonian fluid is investigated by the Network Simulation Method (NSM). The analytical solution introduced by Hayat et al. (2000) [23] has been presented graphically. On the other hand, the provided solution by the network method has also been explained and analyzed. Our aim is to compare both solutions to demonstrate the excellent degree of agreement between the numerical results of Hayat et al. (2000) [23] and the results provided by the NSM. The effect of the parameters such as dynamic viscosity, diffusion coefficient and density involved are reflected in the graphs. Velocity graphs are presented for various values of dimensionless time and spatial coordinates.

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1. Introduction

In recent years, the interest on unidirectional flows has increased significantly. The introduction begins with a recent paper published by Erdogan [1] who studied the initiation of motion of a flat surface. Previously, Rajagopal [2] investigated the exact solutions for a class of unsteady unidirectional flows of a fluid of second grade, in four different flow situations. Currently, in industrial applications, non-Newtonian fluids are more appropriate than Newtonian fluids. Consequently, there are numerous studies related to this interesting topic. The work carried out by Fetecau [3] is outstanding because he studied the solutions for some unsteady unidirectional flows of second grade fluids. The movement of a fluid due to the oscillations of a plate, known as Stoke's second problem, besides being a theoretical interest has great practical application. The study of stationary periodic flow of a non-Newtonian fluid between parallel plates was carried out by Siddiqui et al. [4]. These researchers obtained exact solutions through Fourier transformation, considering the flows generated by oscillations of a plate.

Similar work was performed by Brutyan [5]. He investigated the unidirectional flow of a nonlinear viscous fluid in tubes. Bandelli [6] discussed the same subject but with a difference. In their research, the objective was the thermal convection of the fluid at the second level in the context of unidirectional flows. Chen et al. [7] considered a similar study in which they obtained the velocity results and pressure gradient unidirectional flow at steady state for fluids of second grade. According to the present research on the subject of this article, the difficulty of finding a simple model should be discussed to describe the properties of non-Newtonian fluids. In addition, some confusion exists on their classification and the equation that describes its behavior. One of the most popular models of non-Newtonian fluids is the known model as the second grade fluid. The main objective of the discussed work is the determination of the properties of unidirectional flows.

Some work on the second-order fluid can be highlighted. Rajagopal and Gupta [8] discussed the flow and stability of the solution between two parallel rotating plates. On the other hand, Bandelli and Rajagopal [9] also examined unidirectional transient flows of second grade fluid in a domain of one dimension using the method of integral transformations. A more

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