Abstract

In the present thesis, convective flows of the generalized upper convected Maxwell fluids are studied.

The generalizations consist into taking in consideration of memory effects by introducing fractional constitutive equations for the shear stress tensor and thermal flux density vector. Classical constitutive equations of the upper convected Maxwell fluids, classical Fourier's constitutive equation of the heat flux and the classical Cattaneo's constitutive equation of the thermal flux density vector are generalized as fractional differential equations with time-fractional Caputo-Fabrizio derivative operator with non-singular kernel.

In these generalized mathematical models, the history of the velocity gradient and the history of the temperature gradient influence the momentum and thermal transport processes.

Three main problems are investigated, namely:

Heat transfer analysis in convective flows of generalized upper convected Maxwell fluid over an oscillating isothermal vertical plate;

Two-dimensional boundary layer flow of Maxwell fluids described by a non-linear mathematical model with fractional constitutive equations with Caputo-Fabrizio time-fractional derivative;

Two-dimensional natural convection flows of generalized upper convected Maxwell fluids near a vertical plate with constant heat flux.

Solutions of the fractional differential equations of the studied mathematical flow models, along with the adequate initial and boundary conditions are determined by employing the Laplace transform coupled with the generalized method of separation of variables.

Analytical expressions for the velocity, shear stress, thermal flux and temperature fields are determined. In this direction, must be highlighted the obtaining of the inverse Laplace transforms of three types of exponential functions which are new in the literature.

Using the analytical solutions and Mathcad 15' subroutines, the numerical and graphical analysis of the fluid motion and heat transfer process are presented.

The comparisons between behaviors of the fluids described by generalized constitutive equations and classical fluids highlighted the significant differences of two types of fluids. For example, in some flows, the velocity of classical Maxwell fluids can have discontinuities, while the generalized model eliminates this drawback. The analysis shows that the fractional parameter has significant influence on the fluid velocity and heat transfer; therefore the generalized flow models could describe complex transport processes.