Abstract

The main aim of this thesis is to present new exact analytical solutions for different motions of non-Newtonian fluids in which the velocity is given on one part of the boundary and the shear stress on the other part. In **chapter 1** some important concepts regarding Newtonian and non-Newtonian fluids, differential and rate type fluids, some constitutive equations, equations of motion, and some integral transforms are discussed. Then in all the next chapters exact analytical solutions for the velocity field and the shear stress(es) corresponding to some flows in which the velocity is given on one part of the boundary and the shear stress on the other part are established for different kinds of non-Newtonian fluids as well as some fractional models.

In **Chapter 2** exact analytic solutions for helical flows of a second grade fluid between two infinite coaxial cylinders are established. The motion is produced by the inner cylinder that after time $t = 0^+$ applies torsional and longitudinal oscillating shear stresses to the fluid along the common axis and the outer cylinder is at rest. The exact analytic solutions, obtained with the help of Laplace and finite Hankel transforms and presented as a sum of the steady-state and transient solutions, satisfy both the governing equations and all associated initial and boundary conditions. In the special case when $\alpha_1 \to 0$ they reduce to the corresponding solutions for Newtonian fluids. Finally, the effect of various parameters of interest on transient parts of the velocity components, as well as a comparison between second grade and Newtonian fluids, is discussed through graphical illustration.

In **Chapter 3** helical flows for a Maxwell fluid between two infinite coaxial circular cylinders are studied. At time $t = 0^+$, the inner cylinder begins to rotate around its axis and to slide along the same axis due to torsional and longitudinal time dependent shear stresses and the outer cylinder is at rest. Exact solutions obtained with the help of the finite Hankel transform, presented in series form, satisfy all imposed initial and boundary conditions. The corresponding solutions for a Newtonian fluid and large-time solutions are also obtained as limiting cases and the effect of material parameters on the large-time solutions is discussed. Finally, the influence of pertinent parameters on the velocity components and shear stresses, as well as a comparison between Maxwell and Newtonian fluids, is also analyzed by graphical illustrations.

Chapter 4 deals with the study of unsteady flow of a Maxwell fluid with fractional derivative model, between two infinite coaxial circular cylinders, using Laplace and finite Hankel transforms. The motion of the fluid is produced by the inner cylinder that, after time $t = 0^+$, is subject to time dependent longitudinal shear stresses and the outer cylinder is at rest. Velocity field and the adequate shear stress are presented in series form in terms of the generalized G and R functions. The solutions obtained satisfy all imposed initial and boundary conditions. The corresponding solutions for ordinary Maxwell and Newtonian fluids are obtained as limiting cases of general solutions. Finally, the influence of the pertinent parameters on the fluid motion as well as a comparison between the three models is underlined by graphical illustrations.

Chapter 5 concerns the unsteady flow of a generalized Burgers' fluid, between two infinite coaxial circular cylinders. The motion of the fluid is produced by the inner cylinder that, after the initial moment, applies a longitudinal time dependent shear to the fluid and the outer cylinder is at rest. The solutions obtained by means of Laplace and finite Hankel transforms, are presented in series form in term of the usual Bessel functions, satisfy all imposed initial and boundary conditions. Moreover, the corresponding solutions for Burgers', Oldroyd-B, Maxwell, second grade and Newtonian fluids appear as special cases of the present results. For large values of t, they tend to the steady solutions that are the same for all kinds of fluids. Finally, the influence of the material parameters on the fluid motion, as well as a comparison between models, is shown by graphical illustrations.

Chapter 6 is devoted to the study of the flow of a generalized Burgers' fluid, between two infinite coaxial cylinders. The motion is due to the inner cylinder that applies a time dependent torsional shear to the fluid and the outer cylinder is at rest. The solutions that have been obtained, presented in series form in terms of usual Bessel functions $J_1(\bullet)$, $J_2(\bullet)$, $Y_1(\bullet)$ and $Y_2(\bullet)$, satisfy all imposed initial and boundary conditions. Moreover, the corresponding solutions for Burgers', Oldroyd-B, Maxwell, second grade, Newtonian fluids as well as large-time and transient solutions for a generalized Burgers' fluid are also obtained as special cases of general solutions. The effect of various parameters on large-time and transient solutions of a generalized Burgers' fluid is also discussed. Furthermore, for small values of the material parameters, λ_2 and λ_4 or λ_1, λ_2, λ_3 and λ_4, the general solutions corresponding to generalized Burgers' fluids tend to those for Oldroyd-B and Newtonian fluids respectively. Finally, the influence of the pertinent parameters on the fluid motion, as well as a comparison between models, is shown by graphical illustrations.