Abstract

One of the most successful, fascinating and useful applications of Mathematics has been in the study of motion of fluids. About few decades ago phenomena such as Merrington effect, Weissenberg effect, Normal stress effect, Centripetal pump effect etc, which were realized but could not be explained on the basis of viscous fluid theory. When the assumptions of this theory were examined, it was considered feasible to relax the assumption of linearity between stress and rate of strain tensors. The freedom from the bondage of linearity of relationship between stress and rate of strain tensors led to a great deal of creative works in non-Newtonian fluid flow theory. The solutions of problems of engineering interests in the flow of non-Newtonian fluids require that methods be developed for studying the properties of such fluids in configurations others than the classical viscometric fluid flows. Many rheological models have been proposed to describe the mechanical behaviours of non-Newtonian materials but the most important of these are Bingham plastic, Power-law fluid, Oldroyd fluids, Walters fluids, Rivlin Ericksen fluids, micropolar fluids, second-order fluids and anisotropic fluids. In this study, we have chosen the models of second-order fluids and Walters liquid (Model $B'$) with short memories to investigate the flow behaviours in specific problems for different geometries. The thesis consists of seven chapters.

A brief note on the classical linear theory of fluid flow has been given in chapter I with its limitations. The outline of various theories proposed to explain the non-linear effect and their advantages and demerits are given. A brief deduction of the constitutive equation of second-order fluids and Walters liquid (Model $B'$) has been done. In the last sections, a brief review of the relevant literature and the motivation of the present work have been given.

In chapter II, the problem of unsteady free convective oscillatory flow of an elastico-viscous fluid through a porous medium for a rotating fluid bounded by an infinite vertical porous plate in the presence of uniform magnetic field with a constant suction and constant heat flux is investigated. The free stream velocity of
fluid vibrates at a mean constant value. The analytical expression for dimensionless velocity and skin-friction at the wall is obtained. The effects of magnetic parameter, rotation parameter, permeability parameter and elastic parameter on the flow field have been discussed in detail with the help of graphs.

In chapter III, the problem dealing with the steady MHD flow of an electrically conducting visco-elastic second-order fluid through a horizontal channel has been analyzed. It is assumed that the lower plate being a stretching sheet and the upper one being a permeable plate bounded by porous medium in the presence of transverse magnetic field. The fluid motion is due to stretching of the lower plate with injection applied at the upper plate. The governing equations of the fluid have been solved by regular perturbation method for small value of stretching Reynolds number. The skin-friction coefficients at both the surfaces of the channel are derived and discussed numerically through tabular forms for different values of visco-elastic parameter. The analytical expression for pressure distribution has also been calculated and presented graphically for various visco-elastic parameters involved in the solution.

In chapter IV, the steady free convective MHD flow of an elastico-viscous fluid through a porous medium, occupying a semi-infinite region of the space bounded by a uniformly moving infinite vertical porous plate in presence of a magnetic field with constant heat flux has been investigated. A uniform magnetic field and the suction velocity applied normal to the plate. The regular perturbation technique has been used to obtain governing equations with Eckert number as perturbation parameter. The coefficient of skin-friction has been calculated at the plate and the results are expressed in tabular forms for different values of the visco-elastic parameter. The expression for temperature distribution has also been calculated and presented graphically for several sets of values of the various parameters involved in the problem.

In chapter V, The steady two-dimensional free convective MHD flow of an electrically conducting visco-elastic second-order fluid confined in a vertical wavy channel has been investigated analytically. The equations governing the fluid flow and heat transfer have been solved subject to the relevant boundary
condition by assuming that the solution consists of a mean part and a perturbed part as the walls are pure sinusoidal wavy perturbations to the planes \( y = \pm 1 \). It is also assumed that one of the walls is isothermal and the other is adiabatic. The analytical expressions for dimensionless velocity and temperature fields have been obtained and these results have been numerically worked out for different values of parameters involved in the solution. The first-order velocity components have been presented graphically for various visco-elastic parameters. The important characteristics of the problem, the skin-friction coefficient and the rate of heat transfer at both walls have been discussed in details.

In chapter VI, the steady laminar flow of a visco-elastic fluid between two parallel porous discs when upper disc is rotating moderately and the fluid is injected at uniform rate through both the discs, has been investigated analytically. The governing equations have been solved by perturbation method, taking cross flow Reynolds number as perturbation parameter. The analytical expressions for radial and transverse, velocity components have been obtained and these results have been numerically worked out for different values of parameters involved in the solution. The expression of pressure coefficient and skin-friction coefficient at the lower disc has been obtained, discussed numerically and presented graphically for various visco-elastic parameters.

In the Chapter VII, the paper presents the study of flow and heat transfer characteristics in a visco-elastic Walter's \( B' \) fluid between two co-axial porous rotating discs of different transpiration is considered for small cross flow Reynolds numbers. The discs are rotating with different angular velocities and they are maintained at different but constant temperatures while rate of injection of the fluid at one disc is different from the rate of suction at the other disc. The problem is solved by perturbation technique, taking cross flow Reynolds number as perturbation parameter. The expressions for radial, transverses, axial velocity components and temperature have been obtained and numerical results have been worked out for different values of parameters involved in the solution. The skin-friction coefficient and Nusselt number have also been calculated at both the discs for various cases and these results are expressed in a tabular form. The first order
components of velocity have been presented graphically for different values of visco-elastic parameter.

The thesis is appended with a wide range of bibliography on the subject dealt in various chapters.

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