ABSTRACT

The thesis consists of a study of some problems of flow in second-order fluids. It runs into nine chapters. The first chapter is introductory and deals with the fundamental concepts of flow and heat transfer in the non-translations (mainly in cylindrical system of co-ordinates) of the governing equations (consisting of the constitutive equation and equations of conservation of mass, momentum and energy) for the second-order, Rivlin-Ericksen and electrically conducting incompressible second-order fluids.

The subsequent content of the thesis, which forms the main contribution, is classified under part A and part B, which deals with the flow and heat transfer respectively. Part A consists of four chapters and Part B consists of four more chapters.

The equations involved in the thesis have been non-dimensionalized and the interpretation of the results is based wherever possible on the experimental values of the material constants by the experiments conducted by Markowitz (see Truesdell [1]) for the solution of poly-iso-butylene in cetane at 30°C for different concentrations.

The brief outlines of the chapters in part A and part B are as follows:

Chapter II is devoted to the study of the problem of the flow of an incompressible non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs. The flow functions H, G, L and M are expanded in the powers of the amplitude ε (taken small) of the oscillations. The steady and unsteady parts of radial, transverse and axial velocities have been calculated successfully. The behaviours of the radial, transverse and axial velocities at different values of Reynolds number R, phase difference τ and second-order parameters τ₁, τ₂ has been studied and shown graphically. The transverse shearing stress and moment on the lower and upper discs have also been obtained.
The study of the flow of a second-order fluid between torsionally oscillating discs of different permeability by the perturbation technique is the subject matter of the chapter III. The flow of an incompressible second-order fluid due to torsional oscillations of two infinite discs subjected to rate of suction at the upper disc which is different from the injection rate at lower disc, has been considered by expending the velocity components and pressure in powers of the amplitude of oscillation. The steady and unsteady parts of radial, transverse and axial velocities have been calculated successfully. The effects of second-order parameters $\tau_1, \tau_2$, phase difference $\tau$ and different permeability on radial, transverse and axial velocities are shown graphically. The results obtained are compared with those for a Newtonian fluid.

Chapter IV deals with the study of the problem of the flow of an counter torsionally oscillating discs with different permeability. The flow functions $H, G, L$ and $M$ are expanded in the powers of the amplitude $\epsilon$ (taken small) of the oscillations. The steady and unsteady parts of radial, transverse and axial velocities have been calculated successfully. The behaviours of the radial, transverse and axial velocities at different values of Reynolds number $R$, phase difference $\tau$ and second-order parameters $\tau_1, \tau_2$ has been studied and shown graphically. The transverse shearing stress and moment on the lower and upper discs have also been obtained.

The subject matter of the chapter V is the problem of flow of a non-Newtonian second-order fluid in a porous annulus by finite difference technique. The behaviour of velocity functions has been studied for different sets of values of Reynolds number $R$, elasto-viscous parameter $\tau_1$ and cross-viscous parameter $\tau_2$ and is shown graphically. It is worth mentioning that the numerical technique (Generalized Newton-Raphson) is fast converging and capable of solving a quite difficult set of non-linear equations to a good degree of accuracy in little iterations.

Chapter VI deals with the problem of heat transfer in the flow of an incompressible non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs. The flow functions $H, G, L$ and $M, \Phi, \Psi$ are expanded in the powers of the amplitude $\epsilon$ (taken small) of the
oscillations. The behaviour of the temperature profile has been studied for the different values of Reynolds number \( R \), phase difference \( \tau \), and elasto-viscous parameter \( \tau_1 \) is shown graphically. Nusselt number at lower and upper discs has also been calculated and their behaviour is represented graphically.

Chapter VII deals with the problem of heat transfer in the flow of an elasto-viscous fluid through a channel with walls of different permeability under a transverse magnetic field by regular perturbation technique. The second-order effects on the temperature profile are illustrated graphically for different values of the Hartmann number \( S \), suction parameter \( N \) and Reynolds number \( R \). The results are also obtained for the Newtonian fluid by taking the second-order parameter to be zero.

The subject matter of the chapter VIII is the problem of heat transfer in the flow of an incompressible non-Newtonian second-order fluid between two enclosed torsionally oscillating discs with different permeability in the presence of magnetic field. The flow functions \( H, G, L, \) and \( M, \Phi, \psi \) are expanded in the powers of the amplitude \( \epsilon \) (taken small) of the oscillations. The behaviour of the temperature profile has been studied for the different values of \( N \), phase difference \( \tau \), magnetic field \( m \) and elasto-viscous parameter \( \tau_1 \) is shown graphically. Nusselt number at lower and upper discs has also been calculated and their behaviour is represented graphically.

At finally Chapter IX deals the problem of heat transfer in the flow of an incompressible non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs with uniform suction and injection in the presence of magnetic field. The flow functions \( H, G, L \) and \( M, \Phi, \psi \) are expanded in the powers of the amplitude \( \epsilon \) (taken small) of the oscillations. The behaviour of the temperature profile has been studied for the different values of \( N \), phase difference \( \tau \), magnetic field \( m \), and elasto-viscous parameter \( \tau_1 \) is shown graphically. Nusselt number at lower and upper discs has also been calculated and their behaviour is represented graphically.
The whole work reported in the text is based on the following research papers:

I  Flow of a non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs.  
Int. J. M. S. E. A, 2(4) 2008, 113-128

II  Flow of a second-order fluid between torsionally oscillating discs of different permeability.  
Int. J. M. C. S & I. T, 1(1) 2008, 103-122

III  Flow of a non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs with different permeability.  
(Communicated)

IV  Numerical solution of the flow of a non-Newtonian second-order fluid in a porous annulus.  
(Communicated)

V  Heat transfer in the flow of a non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs.  
Int. J. D. F, 4(2) 2008, 145-157

VI  Heat transfer in the flow of an elastico-viscous fluid through a channel with walls of different permeability under a transverse magnetic field.  
(Communicated)

VII  Heat transfer in the flow of a non-Newtonian second-order fluid between two enclosed torsionally oscillating discs with different permeability in the presence of magnetic field.  

VIII  Heat transfer in the flow of a non-Newtonian second-order fluid between two enclosed counter torsionally oscillating discs with uniform suction and injection in the presence of magnetic field.  
(Accepted in Int. J. D. F)