SYNOPSIS

In the flow of fluids through elastic tubes, the elasticity of the tube plays a prominent role. The shape of the tube gets affected by the different conditions under which the flows take place. It has been investigated in the present work on 'FLOW THROUGH ELASTIC TUBES', how the shape of the tube is affected by the flow conditions and how the elasticity of the tube affects the velocity field. Flexible tubes are involved in many technological and physiological processes, for example, flow of water and oils through rubber tubes in industry and the flow of blood through arteries etc. Hence the effect of such flows on the shape of the tube is worthy of consideration.

The present thesis is divided into five chapters. In Chapter I, the influence of elasticity on the fluid flows, has been discussed in detail. The equations of elasticity for the tube have been deduced. By assuming that the material of the tube is governed by Hooke's Law, a linear stress-strain law for the elastic tube has been obtained following Morgan (1952). Also the equations of motion of the tube-wall during flows involving wave-propagation, have been deduced following Timoshenko (1940). These equations of elasticity together with the hydrodynamic equations of flow constitute the equations of motion for the elastic flows discussed in this thesis. In the subsequent chapters it has been shown how the two systems of equations viz., the equations of elasticity of the tube and the hydrodynamic equations of the flow can be connected together by means of terms involving the fluid stresses on the tube-wall. The solutions of these equations of motion have been obtained by an iteration method which consists in approximating the steady state of motion by expressions which represent essentially the flow in a rigid tube in the first approximation and then obtaining second approximations by computing the values of all the terms involved from the first approximation. The equations of motion for the elastic flows have been solved in certain specific cases in the problems dealt with in the subsequent chapters.

In Chapter II, the steady laminar flow of a non-Newtonian liquid through an elastic tube has been discussed. Non-Newtonian liquids which are highly viscous liquids like blood, paint, thick oils etc. exert normal stresses on the tube-walls during their flow. These normal stress-effects are known as cross-viscous effects and in Chapter II, this cross-viscous effect on the shape of the tube is found to have a tendency to increase the radius of the tube as the distance along the axis increases. Conditions are examined under which an approximate relation between the radius of the tube and the distance along the axis is consistent with the assumptions made in the solution. These conditions are reduced to relations between three dimensionless parameters of the system. Second approximations are found for three different ranges of values of these parameters.

In Chapter III, Acoustic streaming in a viscous liquid contained in an elastic tube has been investigated. When plane progressive sound waves pass through liquids they impinge on the liquid surface imparting acceleration to it and hence the liquid begins to stream. This phenomenon is known as acoustic streaming and is known to be a steady phenomenon since the time of Faraday (1831). The theory of streaming developed in Chapter III, is based on the concept of a time-independent gradient of radiation pressure and has been quantitatively established by a solution of the Navier-stokes equations by taking into account the Poisson's ratio, Young's modulus of the material of the tube and also sound absorption in liquids. It is found that streaming velocity depends more on the elasticity of the tube than on sound absorption.

In Chapter IV, the steady laminar flow of an incompressible viscous liquid through an elastic tube whose walls are maintained at a constant temperature-gradient along the length of the tube has been discussed. Approximate expressions for the temperature distribution and also the relation between the radius of the tube and the distance along the axis have been obtained. It is found that the effect of the presence of the constant temperature-gradient along the length the tube is to increase the radius of the tube as the distance along the axis increases as in the case of the cross-viscous effect in non-Newtonian flow discussed in Chapter I.

Chapter V has been devoted to the discussion of a steady laminar compressible flow of a viscous perfect gas through an elastic tube. By an iteration process, an expression for the relation between the radius of the tube and the distance along the axis has been obtained. The radius of the tube is found to diminish as the distance along the axis increases as in the case of incompressible flow. Conditions are examined under which the approximate relation between the radius and the distance along the axis of the tube is consistent with the assumptions made in the solution. These conditions are reduced to relations between two dimensionless parameters of the system. Second approximations are found when these conditions are satisfied.

The heat energy content, enthalpy per unit mass of the fluid is given by

$$i = \frac{\gamma}{\gamma - 1} \frac{P}{\rho} ,$$

where $\gamma = C_p/C_v$ ratio of the specific heats, P = fluid pressure and ρ = density of the fluid. An approximate expression for the enthalpy i has also been obtained in Chapter V. The enthalpy over any cross-section of the tube is found to increase radially outwards from its centre, while in the direction of the axis, it is found to diminish as the distance along the axis increases.

Numerical examples have been worked out in the cases of the above problems for illustrating the results obtained.