SYNOPSIS

In recent times, the problem of boundary layer control with suction or injection has become important in view of its application in aeronautical engineering in the design of air craft wings, transpiration cooling of rocket engines and in diffusion technology. The theoretical investigation of viscous flows with suction becomes even more complicated than in the case without suction. The present dessertation comprising of six chapters deals with problems on viscous flows with suction or injection. The following two types of problems have been considered -

1) problems on commencement of flows
2) steady flow problems.

The first kind of problems dealt with in Chapters I — III have been solved either by the method of Laplace-transform or by the method of successive approximations. The specific problems discussed in Chapter I are -

a) flow formation in Couette flow
b) flow formation in an annulus.

In both these problems one of the parallel boundaries is started to move from rest with the velocity as a general function of time while the other is kept fixed and uniform suction is applied to the moving boundary. General formulae for the velocity distribution have been derived by Laplace-transform technique. Flow formation when the motion is started impulsively from rest has been discussed as a particular case. The corresponding results without suction have been deduced which agree with the known results. In Chapter II solution has been obtained for the unsteady circulatory flow about a circular cylinder. Such a flow is generated by applying suction to the cylinder at rest and then giving it an impulsive twist such that it starts rotating with a uniform angular velocity. Exact solutions of the Navier-Stokes equations have been derived which tend to the steady state as $t \to \infty$. Graphs have been drawn showing how the steady state is reached. It has been found that steadiness spreads from infinity towards the cylinder.

Chapter III deals with the problem of commencement of boundary layer in two-dimensions with suction, when the relative motion of a viscous incompressible fluid and a cylinder or arbitrary shape is started from rest. Velocity distribution in the boundary layer has been obtained by the method of successive approximations originally due to Blasius, to determine the time that elapses from the start of the motion till the beginning of separation. Results have been applied to a circular cylinder which demonstrate the effect of suction to delay separation.

The second type of problems concerning steady flows have been discussed in Chapters IV — VII. Chapter IV is devoted to a discussion of the general two-dimensional problem for steady laminar flow of a viscous compressible fluid with suction using modified Kármán - Pohlhausen method due to Torda. In particular, velocity distribution in the boundary layer for flow over a semi-infinite flat plate with constant suction has been obtained in a closed form. Expressions for the boundary layer thickness and the average coefficient of skin-friction have been obtained. Boundary layer thickness decreases while average coefficient of skin-friction increases as suction increases.

In Chapter V effect of suction on the temperature distribution ahd heat transfer for flow through an annulus with porous walls or through a channel with rectangular walls has been considered. Rate of suction at one wall has been assumed equal to rate of injection at the other. In the particular case when the two walls have equal temperature it has been found that the point of maximum temperature moves towards the suction wall getting closer to it as the suction velocity increases.

Effect of suction on the flow near a stagnation point has been studied in Chapter VI. Such a flow occurs when a fluid stream impinges on a wall placed perpendicular to the direction of flow. It is well known that the complete Navier-Stokes equations in this case can be reduced to a set of two ordinary non-linear differential equations. These equations with the additional condition of suction at the wall have been integrated on a Digital Computer for various values of the suction parameter.

For large values of the suction parameters, a series solution in inverse powers of the suction parameter has been obtained.