ABSTRACT

The present thesis investigates finite difference solution of the transient free convective flow of a viscous incompressible fluid past an impulsively started semi-infinite vertical plate. Here two types of problems are considered. One problem deals with heat and mass transfer and the other deals with heat and mass diffusion of the chemically reactive species.

Initially, the plate and the fluid are of same temperature and concentration in a stationary condition. When the plate starts moving impulsively in the vertical direction with uniform velocity against the gravitational field, the temperature of the plate and the concentration of the diffusing species near the plate are raised, resulting in the natural convection due to both temperature and concentration differences. The simultaneous heat and mass transfer effects with/without chemical reaction are studied. In the analysis, we make use of the usual assumptions of Boussinesq's and boundary layer approximation. Dissipation due to frictional heating is assumed to be negligible and the concentration of the diffusing species in the binary mixture is very less when compared to other chemical species which are present in the fluid.

The dimensionless governing equations are unsteady, laminar, two dimensional, coupled and non-linear differential equations. An implicit finite difference scheme of Crank-Nicolson type is employed to solve the equations under the prescribed initial and boundary conditions. It has been proved that the finite difference scheme is unconditionally stable.
The numerical solution of flow past an impulsively started semi-infinite vertical plate with heat and mass transfer has been studied for different boundary conditions. The first problem refers to the thermal condition and concentration of the diffusing species on the surface and are assumed to vary as some power of the axial coordinate. The second problem deals with the uniform plate temperature and mass flux.

The flow past an impulsively started semi-infinite vertical plate in the presence of the first order homogeneous chemical reaction between the diffusing species and the fluid is also considered. Two methods are presented for the problem, one for an uniform surface heat flux with mass diffusion and the other for a simultaneous effect of uniform heat and mass flux. The numerical results in all cases are presented in the form of graphs for various values of the parameters. An exact solution of flow past an impulsively started infinite vertical plate with simultaneous effect of uniform heat and mass flux has been presented using the Laplace transform technique.

In order to ascertain the accuracy of our numerical results, the present studies are compared with available theoretical solutions in the literature and they are found to be in good agreement. The time taken to reach the steady-state is observed for different values of parameters. The fluids considered in this study are air and water. The effect of the velocity, temperature and concentration fields in the transient and steady-state are studied. Local as well as average skin-friction, Nusselt number and Sherwood number are computed and shown graphically.