ABSTRACT

Flow separation in viscous flow is of common occurrence and have many practical applications. Separation occurs due to the presence of adverse pressure gradient. This adverse pressure gradient retards the fluid in the boundary layer. There are two kinds of flow separation i.e., internal flow separation and external flow separation. Two numerical codes have been developed for studying unsteady flow separation problems. The flow past a bluff body is another kind of flow separation and the corresponding wake characteristic parameters have been computed.

In the first part of the thesis (Part A), primitive variable approach in staggered grid has been used for the study of separated flow problems. For internal separated flow, unsteady Navier-Stokes equations in cylindrical polar coordinates have been solved numerically. A coordinate transformation has been used to map the infinite domain with constriction into a finite rectangle. A modified pressure Poisson equation and pressure-velocity correction formulae have been derived. Satisfactory level of convergence e.g. mass conservation of order 0.5×10^{-5} has been achieved. The wall vorticity values (in magnitude) increase rapidly when the flow approaches the constriction and attain a peak value near the maximum constricted area. Downstream, the wall vorticity values decrease sharply and remain negative in the separated region. The streamlines, vorticity contours and pressure distributions have been presented graphically for several cases of constriction.

For the external separated flow, two dimensional unsteady Navier-Stokes equations in body-fitted curvilinear orthogonal coordinates have been solved. Both the numerical codes (internal and external flows) are very effective for reducing the divergence value even at the separated flow region. It has been successfully implemented for the investigation of unsteady separated flow at low and high Reynolds numbers. The periodic flow, vortex shedding frequency and unsteady wake characteristics have been investigated in details. Secondary

eddies are formed at the Reynolds number 200 but appear periodically . It is noted that the secondary eddies are sustained at higher Reynolds numbers. A typical case study for flow past an elliptic cylinder has been carried out.

It may be mentioned that in view of limited computational facilities, the present study is restricted to laminar separated flow problems only.

In the second part of the thesis (Part B), convective mass transfer and thermal instability in Bénard-Marangoni system have been presented. The dispersion of a passive contaminant (solute) in a flowing fluid has a wide application in real situations. The rotational effect on solute dispersion in parallel plate channel has been investigated. It is noted that the longitudinal dispersion coefficient K_2, which is a function of time, decreases with increase of rotational parameter. Thereafter it increases with the increase of rotational parameter. The combined effect of rotation and magnetic field on solute dispersion in a conducting fluid has also been investigated in the present work and the conflicting tendencies of the velocity field as well as the solute dispersion are studied in detail. Thermal instability in Bénard-Marangoni system of a deformable free surface, heated from the lower surface, has been studied by allowing the variation of density and surface tension with temperature and concentration gradients. The instability arising out of a deformed free surface has led nonlinear waves like Bergers and Korteweg-de Vries (KdV). The stability condition of the system and the critical Rayleigh number for the evolution of nonlinear waves have been derived in the present work. The zone for the Soret number 0, where the Bergers equation holds, is unbounded. The analysis reveals that for the Soret number 1, that unlike the unbounded Burgers domain found in the absence of buoyancy forces, the Burgers domain in the presence of buoyancy forces is bounded by a parabola. It is a hyperbola when the Soret number is not equal to 0 or 1.