Abstract

Vortex flows are fundamental to nature and technology. In this dissertation, the results of an experimental and numerical investigation into the behaviour of the free vortex generated by shock diffraction over edges yawed to the incident shock wave are presented. The objectives of this study were to explore the behaviour of the free vortex in three dimensions, with a particular focus on the distortions caused to the vortex by the presence of a solid boundary, or wall. Three-dimensional numerical simulations and experimentally obtained schlieren photographs reveal significant distortion and bending of the free vortex in regions near the boundary of the flow domain, so as to meet it at a right angle. Experimentation was performed in a shock tube for incident shock Mach numbers of 1.32, 1.42, and 1.65, with four test models, two incorporating straight diffraction edges, and two incorporating curved diffracting edges. Numerical simulation was performed with Fluent 6.3.26 software. The numerical solutions were validated against the experimental results through pictorial comparison, and despite relatively coarse meshes being used, were found to mimic the experimental results very well. The numerical results are used here to investigate and explain the various features of the resultant flow fields, with particular emphasis placed on the behaviour and properties of the free vortex. The effects of bending on the structure of the vortex and on the flow properties with the vortex are examined. The rate of circulation production for the three-dimensional diffraction cases was calculated, and the trends observed correlated with those for the much published two-dimensional diffraction case. Also investigated is the three-dimensional shock diffraction case, where it was found that the shape of the diffracted shock wave differed slightly from the two-dimensional case in the region near the boundaries of the domain.