Abstract

In this thesis, compressible round jets are studied using DNS and LES.

Large eddy simulations of subsonic round jets are carried out using high order compact finite difference scheme and an explicit filtering based approximate deconvolution method. The jets have a Mach number of 0.9 and Reynolds number of 4.5×10^5 based on jet diameter and centerline velocity at inflow. Results obtained for the mean flow and turbulence intensities agree well with those in existing literature. We also study the effects of co- flow velocity ratio on the flow physics. Increase in potential core length and decrease in spreading rate of jet is observed in the presence of co-flow. The effects of co-flow velocity ratio on the axial Reynolds stress and turbulent kinetic energy budgets are also presented. It is observed that increasing co-flow velocity ratio leads to reduction in the turbulence intensities and near-field sound levels.

After analyzing the near field of round jet, the focus is shifted to far field acoustics. The far field acoustics of the jet is simulated by solving isentropically linearized Euler equation (ILEE) using the same high-order compact finite difference scheme as the near field LES. The effect of one-way and two-way coupling on jet near and far field is analyzed for both subsonic and supersonic round jet. The effects are shown for centerline velocity, Reynolds stresses, near field sound pressure levels and far field sound pressure levels. Using the results obtained from two-way coupled simulation, the effect of the value of constant sigma (σ) which appears in the partially non reflecting boundary condition at the radial boundary of near field LES simulation is also analyzed.

Now, we shift our focus from aeroacoustics of compressible round jets at moderate Reynolds number towards the physics of flow entrainment by compressible round jet. Direct numerical simulation of a compressible round jet is carried out at Mach number of 0.9 and Reynolds number of 3600 and the data is used to perform velocity gradient tensor (VGT) analysis for different regions of the spatially developing jet. For the developed portion of the jet, the classical teardrop

shape is observed for the joint pdf of Q and R (second and third invariants of the VGT). In the region just after the potential core, between X = 10 to 15 r_0 (r_0 is the jet inlet radius), an inclination towards the third quadrant is observed in Q-R joint pdf which represents the presence of tube-like structures. It is also shown that this inclination in the T/NT boundary and interface towards the third quadrant is a contribution of points that lie in regions with negative dilatation. Points that lie in regions with positive dilatation show no such inclination towards the third quadrant but are inclined towards the fourth quadrant which indicates the presence of sheet-like structures. Similarly for the domain segment X = 15 to 20 r_0, it is observed that points that lie in the regions with positive dilatation have a joint pdf with an inclination towards fourth quadrant, which suggests the presence of sheet- like structures at the T/NT boundary and interface. Points that lie in regions with negative dilatation show the appearance of a lobe in the third quadrant.