CFD ANALYSIS OF OVER-EXPANDED FLOW IN CONVERGENT DIVERGENT NOZZLES

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Abstract

The classical one-dimensional inviscid theory does not reveal the complex flow features in an over-expanded nozzle accurately. The code Fluent has been used to simulate the viscous fluid (air) flow passing through three different 2-D Convergent-Divergent (C-D) nozzles for nozzle pressure ratios (NPR) corresponding to over-expanded flow. The steady state RANS equation with five different turbulence models has been simulated for turbulence model study. Two different types of boundary layer grids: grid1 ($y_+=1$) and grid 2 ($y_+=50$) have been simulated. Shear Stress Transport k-ω (SSTKW) turbulence model with grid 1 has been chosen for turbulence modeling. Both inviscid and viscous flows have been simulated. The converged solutions captured asymmetric lambda shock in all the three nozzles at higher NPRs for viscous flows. It also predicted aftershock and flow separation depending upon NPR. The shock wave angle of the incident and reflected shock generally reduces with increase in NPR for NPR≤1.92. The thrust co-efficient of all the theoretical, predicted inviscid and predicted viscous solutions reduce with increase in NPR upto a certain value of NPR and then starts increasing. The predicted viscous results (shock structure, shock location, size of normal shock, aftershock and asymmetric lambda shocks) are close to the experiments in most of the cases. The aftershock phenomenon provides dual mode flow at the exit of the nozzle.

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