Modelling flow and acoustics in a constricted pipe at low Mach numbers is important for investigating many physiological phenomena such as phonation, generation of arterial murmurs, and pulmonary conditions involving airway obstruction. The objective of this study is to validate computational fluid dynamics (CFD) and computational aero-acoustics (CAA) simulations in a constricted tube at low Mach numbers. Different turbulence models were employed to simulate the flow field. Models included Reynolds Average Navier-Stokes (RANS), Detached eddy simulation (DES) and Large eddy simulation (LES). The models were validated by comparing study results with laser doppler anemometry (LDA) velocity measurements. The comparison showed that experimental data agreed best with the LES model results. Although RANS Reynolds stress transport (RST) model showed good agreement with mean velocity measurements, it was unable to capture velocity fluctuations. RANS shear stress transport (SST) k-ω model and DES models were unable to predict the location of high fluctuating flow region accurately.

CAA simulation was performed in parallel with LES using Acoustic Perturbation Equation (APE) hybrid CAA method. CAA simulation results agreed well with measured wall sound pressure spectra. The APE acoustic sources were found in jet core breakdown region downstream of the constriction, which was also characterized by high flow fluctuations. Proper Orthogonal Decomposition (POD) is used to study the coherent flow structures at the different frequencies corresponding to the peaks of the measured sound pressure spectra. The study results will help enhance our understanding of sound generation mechanisms in constricted tubes including biomedical applications.

Major: Aerospace Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2013, University of Moratuwa, Sri Lanka

Committee in Charge:
Hansen Mansy, Chair, Mechanical & Aerospace Engineering
Samik Bhattacharya, Mechanical & Aerospace Engineering
Alain Kassab, Mechanical & Aerospace Engineering

Approved for distribution by Hansen Mansy, Committee Chair, on October 18, 2017.

The public is welcome to attend.