Aerodynamic Noise Prediction for a Rod-Airfoil Configuration using Large Eddy Simulations

On behalf of Professor Anupam Sharma, Meet our graduate candidate:

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*** Noise produced by aerodynamic interaction between a circular cylinder (rod) and an airfoil in tandem arrangement is investigated using large eddy simulations. The quasi-periodic shedding from the rod and the resulting wake impinging on the airfoil produce unsteady forces on the rod and the airfoil respectively. These unsteady forces acts as sound sources which radiate sound to farfield. This rod-airfoil interaction problem is a model problem for studying noise generation due to inflow turbulence interacting with a turbomachine bladerow or a wind turbine rotor. The pimpleFoam (part of OpenFOAM) and Charles (developed by Cascade Technologies) solvers are chosen to carry out incompressible and compressible large eddy simulations (LES) respectively. The airfoil is set at zero angle of attack for the simulations.

The flow conditions are specified by the Reynolds number (based on the rod diameter), Red = 48, and the flow Mach number, M∞ = 0.2. Comparisons with the measured data are made for (a) mean and root-mean-squared velocity profiles in the rod and airfoil wakes, (b) velocity spectra in the near field, and (c) far-field pressure spectra and directivity. Near-field, off-surface flow data from Charles simulation and on-surface airfoil pressure data from pimpleFoam simulation are used with the Ffowcs Williams-Hawkings (FW-H) acoustic analogy and Amiet’s theory respectively to predict far-field sound. The flowfield data and spectral analysis compares well against the experimental results for the two approaches: compressible and incompressible CFD solvers coupled with FW-H and Amiet’s theory respectively.