Computational Aeroacoustic-Noise Prediction using Hybrid Methodologies

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The main goal of this thesis is to develop an efficient numerical algorithm to compute the radiated far field noise provided by an unsteady flow field from bodies in arbitrary motion, building up the necessary know-how to perform Computational Aeroacousstic (CAA) calculations. The aeroacoustic simulation for practical applications can only be carried out with the hybrid approach, which separates the problem into two or more parts, one describing the nonlinear generation of sound, the others describing the transmission of sound. The hybrid approach investigated in this work simulates the acoustic far field using a two step procedure.

In the first step, a turbulent flow field is computed in a flow simulation using a CFD method, which is capable to resolve the turbulent scales responsible for the noise generation. This computation comprises the acoustic sources under consideration via a large eddy simulation (LES) solver. Since the subgrid scale (SGS) models play an important role in improvement of quality of LES, different SGS models will be evaluated during the calculations. The time-dependent quantities of dynamical fluctuations in the near field are the source information for the radiated acoustic far field and are stored in a data base. In the second step, an acoustic computer program is used to calculate the far field sound pressure based on the acoustic source information provided by the first step simulation.

The Ffowcs-Williams and Hawkins (FW-H) approach with a solid and/or permeable data surfaces is chosen to carry out the second step. Three integral formulations of the FW-H approach, namely the 3D Farassat's formulations, are implemented into the computer program.

In order to investigate the computational parameters for aeroacoustics and to obtain an optimization concept of the numerical calculation, several verification and validation test cases are defined and assessed. The performance of this hybrid methodology is shown by predicting the noise generated from flow around a circular cylinder at different Reynolds numbers.