Hessisches Kompetenzzentrum
für Hochleistungsrechnen

Simulation of Flow-Induced Noise and Vibration for Turbulent Flows

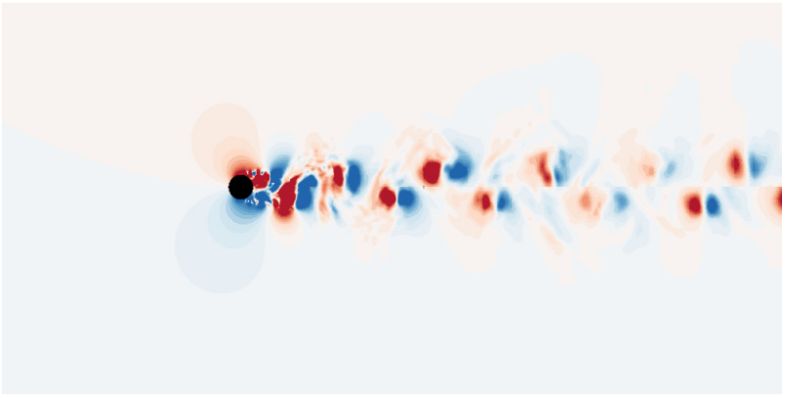


Figure 1: Distribution of acoustic source term in the wake of a cylinder

Introduction

The turbulent flow around blunt bodies induces aeroacoustic sources due to the interaction of the fluid with geometrical components and the production and decay of turbulent structures. This so-called flow-induced sound is a major noise source caused by technical applications, such as wind turbines or aircraft wings. While the majority of acoustical research is focused on stationary geometries, surface deformations or low-frequency structural movements induced by fluid-structure interaction (FSI) are rarely considered. The present project aims at developing an approach for the simulation of flow-induced noise generated by the interaction of turbulent flows with moving or flexible structures.

Methods

Some of the most promising and commonly used numerical techniques in computational aeroacoustics are hybrid methods based on an acoustic/viscous splitting approach. In the present project sound generation due to aerodynamics is computed in the in-house finite-volume solver FASTEST via large eddy simulation (LES). Therefore, large-scale fluctuations, which largely contribute to noise generation, are resolved. Acoustic wave propagation is computed with the same software by solving the linearized Euler equations. FASTEST can be coupled with the structural finite-element solver FEAP in order to perform FSI simulations. This is called a partitioned approach as the fluid domain and the structural domain are treated separately. The transfer of computed forces and displacements at the interface of the fluid domain and the structural domain is done via the open-source coupling library preCICE. This framework can also handle interpolation between non-matching grid interfaces.

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Project Term
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Project Areas
Heat Energy Technology, Thermal Machines, Fluid Mechanics

Clusters
Lichtenberg Cluster Darmstadt

Software
FASTEST

Additional Software
preCICE, FEAP

Institute
Fachgebiet Numerische Berechnungsverfahren im Maschinenbau

University
Technische Universität Darmstadt

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN
TECHNISCHE UNIVERSITÄT DARMSTADT
UNIKASSEL VERSITÄT
Philipps Universität Marburg

Results

During the first project phase, the acoustic sound generation and the acoustic wave propagation on moving grids were investigated. An arbitrary Lagrangian- Eulerian (ALE) approach was applied for coupling the fluid and acoustic fields with the mechanical field. The results show that the ALE approach is well suited for computing acoustic sound generation as well as radiation on moving grids. After this successful proof of concept, the aeroacoustic effects induced by a rigid body undergoing a prescribed oscillating motion were investigated. The second project phase involves the application of the developed approach to more realistic problems. Therefore, a suitable test case has to be specified.

Discussion

Combining aeroacoustics and fluid-structure interaction provides a new field of research, located at the intersection of computational aeroacoustics (CAA), computational fluid dynamics (CFD), and computational structural mechanics (CSM). Partitioned approaches allow the use of specialized solvers for each subdomain. The present project aims at developing a partitioned simulation framework for the investigation of flow-induced noise generated by the interaction of turbulent flows with moving structures. This is considered an essential step towards understanding and predicting noise generation for real-world applications.

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