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A NOVEL CAA APPROACH IN OPENFOAM® FOR COMPUTATION OF SOUND FIELDS

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Fluidic products and components e.g. air intake systems emit sound mainly based on turbulences. In product development process the acoustic parameters and the sound emission are often considered not before an existing prototype. Usually changes of concepts are hardly feasible. To avoid this in the development process commonly used numerical methods for continuous mechanics like finite volume methods for computational fluid dynamics are extended to compute e.g. the sound pressure level in the far field at a specific observer point. This data is comparable to the results of common acoustic measurements. Concerning the limitation of existing computation resources hybrid approaches are used. Therefore the fundamental fluid dynamics are computed by unsteady RANS-simulations, where the turbulences are solved by mathematical models on a very fine computation mesh in a relative small domain. The values responsible for sound propagation are transformed to coarser meshes representing the large domain of acoustical far field, or the acoustical investigations are done during the post processing of the CFD results.

The presented computational aero acoustic approach is implemented in the open source computational fluid dynamics framework OpenFOAM® 2.1.1 which is based on [1]. The open source code OpenFOAM® is used to solve complex fluid dynamic problems and has the principle functionality to solve aero acoustic problems as mentioned in [2] and [3].

This novel approach is mainly based on Curle's acoustic analogy [4] which is a special case of the Ffowcs-Williams-Hawkings equation where the regarded surfaces within the computation domain are rigid and stationary. The method also takes the possibility and availability of high performance computing resources into account. Due to HPC resources, the shown method provides the advantage to compute and visualize the flow fields, acoustic sources and the corresponding sound propagation in an extended near field on one mesh only. There is no transformation of the values between different meshes for CFD and CAA necessary.

The CAA approach in OpenFOAM® 2.1.1 [5] is added to transient incompressible and compressible application solvers, pisoFoam and rhoPimpleFoam respectively, which are both parallelized already. The adapted application solver computes the turbulence based acoustic sources and computes the corresponding sound propagation.

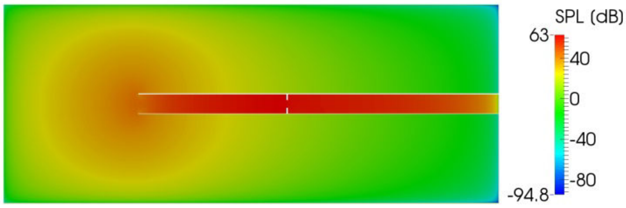

Figure 1: Distribution of Sound Pressure Level SPL [dB] in computation domain

Example simulations of a principle air-intake system for combustion engines showed in Figure 1 using the different adapted application solver in OpenFOAM®, choosing the k-Omega-SST-turbulence model, are carried out. The computed and visualized fields of acoustic sources and sound propagation are studied concerning parallelization, efficiency, scalability, errors and physical plausibility. The simulated results are compared with experimental data. Finally the advantages and disadvantages of the method itself are discussed and a brief outlook on possible application of the method in common development processes is given.

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