RESIDUAL DISTRIBUTION METHOD FOR LINEARIZED EULER EQUATIONS

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Due to the ever more and more restrictive legal regulations regarding noise emissions and human response to noise in domestic areas and working and living environments as well as the growing customer demand for noise comfort, the research in the field of acoustic has grown significantly during the past decades. Acoustic phenomena involve two major components: the source that generates a noise and the noise propagation.

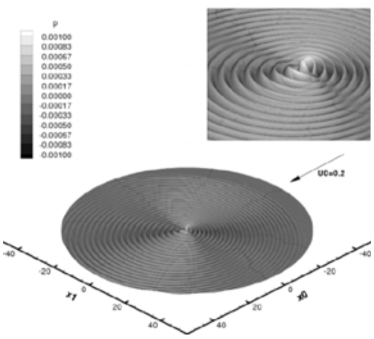
Aero-acoustics problems deal with the analysis of the generation of acoustic waves by an unsteady turbulent aerodynamic field as well as the propagation of acoustic waves in inhomogeneous medium. This project is assuming with one-way coupling between the aerodynamic field and acoustic field using Linearized Euler Equations (LEE).

The project is involved in SBO project CAPRICORN which deals with internal flows, in particular with duct fan. For this kind of flow, a hybrid method is necessary. VKI is involved in the development of a solver using LEE. This is achieved with a residual distribution (RDS) method in COOLFluiD (CFD software developed at VKI). The goal of this project was to implement LEE physical model in COOLFluiD and apply RDS on it.

The method itself (RDS) was already implemented in COOLFluiD. The project task consists of a physical and a numerical part. The first includes understanding of the noise propagation phenomena and choosing a suitable test case set to validate the developed code. The second part contains implementation of the physical model to COOLFluiD. This requires the implementation of LEE and the development of non–reflexive boundary conditions to avoid spurious waves that reflect back to the computational domain. The later is achieved by the so called Sponge zone. To verify our results the Riemann problem, Gaussian pulse, Monopole and dipole was chosen.

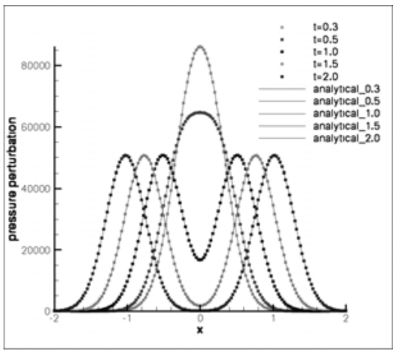
It follows from numerical results that speed of propagation and the properties of the test case physic are captured correctly by our implementation of LEE. The fluctuations are propagated by correct speed what was shown by Riemann problem and Gaussian pulse. The change of wavelength, caused by uniform mean flow is captured correctly also, which was proved by Monopole and Dipole. The amplitude seems to by captured badly. The mistake comes most likely from improper analytical solution. The computed results of Riemann problem or the quasi-1D Gaussian pulse prove that the amplitude dumping is captured well for properly defined cases.

To avoid spurious waves radiated by boundary back to computational domain the Sponge zone method was tested. This treatment of boundary conditions seems to be sufficient for our cases.



(a) Pressure perturbation field resulted from dipole sound source at time t=50s

Figure 1: Some results obtained in this DC project



(b) The quasi 1D Gaussian pulse - a comparison with analytical solution at different time instances