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CFD STUDY OF THE ACOUSTIC PERFORMANCE OF SIMPLE EXPANSION CHAMBER MUFFLERS

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Accurate prediction of the performance of noise-dissipating devices is important to improve the design of automotive exhaust systems. The most common parameter used to describe the acoustic performance is the transmission loss (TL). The TL is the difference in the sound power level between the incident wave entering and the transmitted wave exiting the muffler. The present work describes the application of CFD to analyze the acoustic performance of various simple expansion chamber mufflers. The CFD results are compared with published analytical and experimental results, as well as inhouse FEM simulations which do not take into account viscous dissipation. The time history of the acoustic pressure and particle velocity is recorded at two points, one point at the inlet pipe and one point at the outlet pipe. These time histories are analyzed using the Fourier Transform and the TL of the muffler is calculated.

CFD simulations are performed using an axisymmetric muffler consisting of an entry tube, the expansion chamber and an exit tube. Boundary condition at the entry consists on the superposition of a velocity impulse over a constant velocity flow field. A second-order implicit scheme for the temporal discretization is used and pressure-velocity coupling is done using PISO. A standard RANS turbulent model with improved treatment close to the walls is used. FEM simulations are based on the solution of the wave equation.

The results obtained using the FEM and CFD show good agreement in the general behavior of the TL at a range of frequencies. Nevertheless, the FEM fails to accurately capture some of the features observed experimentally. This is a result of the method neglecting the viscous dissipation in the flow. CFD is able to better predict some of these features but at a much higher computational cost. General recommendations in terms of performance, as well as the time step required to accurately predict the behavior at higher frequencies are presented.