Impact of grid refinement on combustion noise prediction

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The direct noise emission of turbulent combustion processes is primarily induced by the strong temporal and spatial gradients of the flow and state variables in the flame area\(^1\). For large eddy simulation (LES) of turbulent combustion, the thickness of the propagating flame front is generally small compared to the mesh size. Hence, the flame is filtered by the grid cells, where the mesh resolution has a major influence on modeling of the underlying flame/turbulence interaction. The current work applies a hybrid method based on a compressible LES and a computational aeroacoustic (CAA) method to a partially premixed flame\(^2\) on two grids at different refinement levels to assess the impact on the noise generation mechanisms. A instantaneous contour plot of the temperature field for the present flame is depicted in fig. 1(a).

As shown in fig. 1(b), the resolved part of turbulent kinetic energy \(k_{res}\) exhibits higher values for LES on the finer mesh even in the low frequency range. As a result, the unsteady behavior of a turbulent flame is significantly influenced, which leads to a reduced acoustic source mechanism. Fig. 1(c) shows the far field sound pressure level (SPL) \(L_p\) derived from LES on both grids. A broadband impact of the grid resolution on the radiated noise is evident, particularly in the high frequency range that is related to unresolved turbulent scales. In the final work, the LES will be supported by experimental findings. The effect of grid refinement on the noise source mechanisms will be computed by the Acoustic Perturbation Equations (APE)\(^3\) and compared to the classical Lighthill\(^4\) acoustic analogy concept. Detailed analysis of the single source mechanisms for the different grid resolutions will be presented.

Figure 1: Instantaneous contour plot of the temperature field (a), spectra of \(k_{res}\) in the near field (b), and sound pressure level \(L_p\) in the far field (c) for the present flame.

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