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Assessment of numerical approach for coherent Flame Transfert Function comparison between LES and experiments

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The understanding of partially-premixed flame dynamics is of major importance for burner safety, especially with the use of new fuels like hydrogen, ammonia, SAF or blends. These burners often rely on multiple injection lines, for example one to inject hydrogen and one for air. To assess flame sensitivity to perturbations in each line, such as acoustic fluctuations or equivalence ratio stratification, the Multiple Input Single Output (MISO) Flame Transfer Function (FTF) approach is used [1]. For example, in a two-injection-line system, fluctuating heat release (Q') can be linked to the velocity fluctuations (u'_1, u'_2) or velocity and global equivalence ratio fluctuations (u', ϕ') [2]. While suitable for numerics, this method typically relies on 1D acoustic models for the experimental side, to reconstruct fluctuations at each injector exit, and verified only in cold flow conditions. The accuracy of comparisons between LES and experimental data drastically depends on the model's validity in hot flow, which may lead to misleading interpretations. Additionally, the validity of experimental heat release markers, such as OH* for hydrogen and hydrocarbons, introduces another source of error in the qualitative comparison. To address these challenges, a numerical methodology is proposed to compare experimental and numerical FTFs without relying on an incomplete 1D acoustic model. This includes proper acoustic treatment using Delayed-Time Domain Impedence Boundary Conditions (D-TDIBC) [3] to match experimentaly measured waves amplitudes and phases. The OH* species is included in the chemical mechanism, used in simulation, to evaluate the coherence between its fluctuations and heat release ones. Finally, simulations are used *a posteriori* to verify experimental assumptions in both cold and hot flow conditions and, if required, adjust the 1D acoustic model to quantitatively compare velocity fluctuations at reference points. This methodology is applied to an hydrogen-air partially-premixed injector, and ensures a coherent comparison of the MISO FTF obtained from the LES *versus* the experimental one.

References

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