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DNS study of sound generation in turbulent lean premixed hydrogen-air flames

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Combustion noise is a relevant issue for engineering combustion systems [1]. Its investigation via high-fidelity numerical simulations, however, is a computationally expensive task. Therefore, many numerical studies in the literature are based on Large Eddy Simulations (LES) or hybrid approaches combining LES with computational aeroacoustics, while investigations based on Direct Numerical Simulations (DNS) are quite rare, and mostly involve hydrocarbons. In this work, the noise radiated by turbulent lean ($\phi = 0.45$) premixed hydrogen-air flames is investigated by performing DNS in a slot burner configuration at atmospheric conditions (300 K and 1 atm). A subsonic jet of premixed reactant is injected with bulk velocity U_{bulk} and velocity fluctuation $U_p = 0.1U_{bulk}$ through a rectangular nozzle into an open environment of ambient air. First, the impact of Lewis number effects is examined by comparing the hydrogen flame to a stoichiometric methane flame with similar flame properties (i.e., laminar burning velocity and laminar flame thickness). The same mean length of the flame brush is obtained for the two fuels by setting $U^*_{bulk} = 0.4U_{bulk}$ for the methane flame, while keeping the same velocity fluctuation. Subsequently, the impact of the Reynolds number is studied by varying the bulk velocity of the hydrogen flame to the same value of the methane flame. Finally, the impact of density inhomogeneities is analyzed by injecting the jet of premixed reactant into an environment of combustion products at the adiabatic flame temperature. Preliminary results show significant differences between the hydrogen and methane flames in the mechanism of flame surface annihilation, which is known to be a prominent source of acoustic radiation [2]. As for the hydrogen flames, similarities are found in the flame response to turbulence, highlighted by the comparison of heat release rate spectra, while differences are present in the acoustic radiation, especially in the low frequency range. A more intense peak is observed for the first configuration, for which the entrainment of cold ambient air into the hot post-flame region is stronger. Nevertheless, similarities are found at high frequencies, for which the flame/turbulence interaction and the destruction of the flame surface area play a significant role in terms of noise generation [2]. This analysis aims to gain a further understanding of the contribution of different acoustic sources to the overall acoustic radiation of turbulent lean premixed hydrogen-air flames.

References

[1] Dowling AP and Mahmoudi Y. Combustion noise. *Proceedings of the Combustion Institute*. 2015;35:65-100.

[2] Brouzet D et al. The impact of chemical modelling on turbulent premixed flame acoustics. *Journal of Fluid Mechanics*. 2021;915:A3.