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CH_4 / air and H_2 / air Head-On-Quenching flame wall interactions

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The imperative to decarbonize high thermal load applications necessitates the development of new processes with novel designs supported by computational tools that accelerate the transition toward a low-carbon economy. However, these simulations must deliver reliable and predictive outcomes with a high level of confidence.
In addition, numerical simulations offer critical insight into configurations where experimental diagnostics are intrinsically challenging, particularly for transient phenomena [1]. Flame-wall interactions (FWI) present a complex configuration in combustion systems, especially internal combustion engines, with unsteady phenomena, characterized by tightly coupled temporal and spatial scales [1]. Among the canonical configurations adopted to investigate FWI, the one-dimensional head-on quenching (1D HOQ) configuration serves as a relevant benchmark [2, 3], capturing essential features of FWI observed in practical combustion devices and a proper estimation of characteristic quantities [4].
This study investigates numerically the 1D HOQ configuration for methane (CH_4) and hydrogen (H_2) with detailed mechanism, complex transport and finite-rate chemistry by comparing with experimental measurements. The analysis focuses on the characterization of quenching distance and wall heat flux. An exhaustive modeling framework is established, incorporating various modeling approaches, which are validated against the corresponding experimental data for the selected fuels. Moreover, a parametric sensitivity analysis is conducted to evaluate the influence of key operating parameters, including unburnt gas temperature, pressure, and equivalence ratio, on the HOQ configuration.

References

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