Turbulent Flame-wall Interaction of Hydrogen-enriched Ammonia Flames

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Ammonia is gaining increasing attention as an easy-to-store carbon-free fuel. Compared to conventional hydrocarbons, ammonia flames exhibit low flame speeds and thus poor stability. For practical applications, enriching ammonia by hydrogen is therefore often considered. Little work has been done on exploring flame-wall interaction characteristics of ammonia-hydrogen flames. Recently, a series of systematic numerical studies have been conducted to investigate flame-wall interaction in canonical laminar flame configurations, i.e. head-on and side-wall quenching. Wall heat fluxes, quenching distances and pollutant emissions in the quenching zone, especially for NO_x and N_2O, for different hydrogen-ammonia blends were studied [1].
In this work, the investigation of hydrogen-enriched ammonia flame-wall interaction is extended to the turbulent regime, using a blending ratio of $\mathrm{H_2/NH_3} = 0.4/0.6$ by volume at stoichiometry. First, a direct numerical simulation of a turbulent channel flow, following the classical $Re_\tau = 180$ setup by Kim, Moin and Moser, is performed to generate inflow conditions for a second, fully resolved reactive simulation. A flame anchor is placed near the inlet to establish a V-shaped flame, where the upper flame branch interacts with the channel wall. The channel has dimensions of $48\delta_{\mathrm{th}} \times 72\delta_{\mathrm{th}} \times 336\delta_{\mathrm{th}}$ [2], where $\delta_{\mathrm{th}} = 0.45\,\mathrm{mm}$ is the thermal flame thickness of the laminar flame. The inflow and channel walls have a fixed temperature of 500 K. Using an in-house solver [3] and detailed kinetics and diffusion, including the Soret effect, the resolved transient flame-wall interaction is studied by evaluating local flame displacement speeds at different stages of the quenching event to elucidate the relative significance of normal and tangential diffusion, identification of chemical pathways affecting pollutant formation during quenching, and studying wall heat fluxes and quenching distances of the turbulent flame.

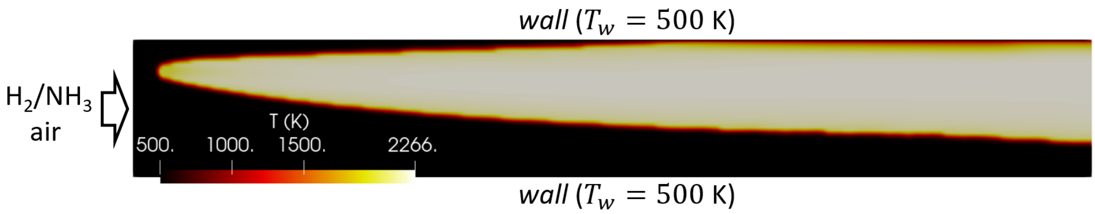

Figure 1: Mean temperature field of the 3D turbulent flame.

References

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