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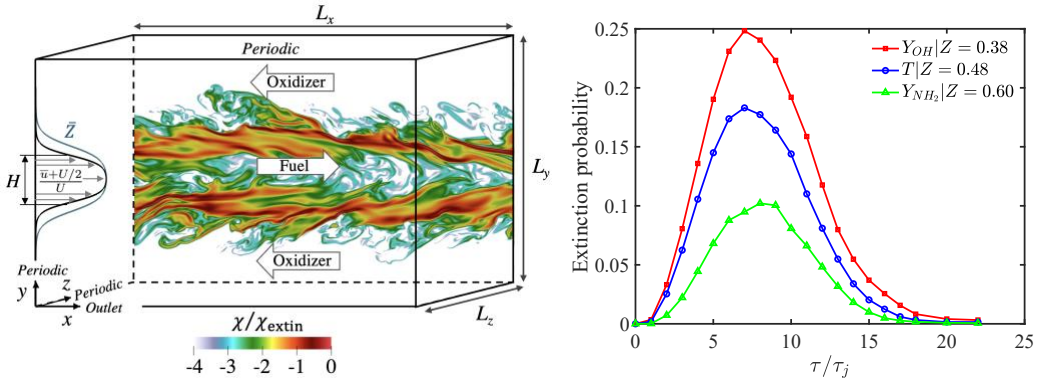
Numerical study of turbulence-chemistry interactions in partially premixed cracked ammonia-air jet flames

Junjun Guo[1,*], Francisco E. Hernández-Pérez[1], Suliman Abdelwahid[1], Hong G. Im[1]
*Lead presenter: junjun.guo@kaust.edu.sa
1 Clean Energy Research Platform (CERP), Physical Science and Engineering Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia

Partial cracking of ammonia presents a practical solution to the challenges associated with its low laminar burning velocity and high autoignition energy. Understanding turbulence-chemistry interactions in partially cracked ammonia-air flames is essential for developing and validating predictive models of turbulent ammonia flames. In this study, direct numerical simulations (DNS) of temporally evolving planar jet flames for partially premixed cracked ammonia-air mixtures were conducted at Reynolds numbers (Re) of 24,000 and 36,000 using the KAUST Adaptive Reacting Flows Solver (KARFS) [1]. The computational domain is shown in Fig. 1(a). The fuel consists of 25.5% H_2, 20.3% NH_3, 44.6% N_2, and 9.6% O_2 by volume, corresponding to a mixture of 43% cracked ammonia and air at an equivalence ratio of 3. The oxidizer is air. These conditions are selected to match those of the turbulent piloted $NH_3/H_2/N_2$-air flames studied experimentally by Tang et al. [2].

The turbulence-chemistry interactions were investigated focusing on localized extinction and reignition phenomena. A previous study [2] under laminar conditions identified three peaks in heat release rate across mixture fraction space, attributed to the differing diffusivity and reactivity of NH_3 and H_2. Localized extinction was analyzed at these representative locations, corresponding to the peak OH on the fuel-lean side, peak temperature near the stoichiometric mixture fraction (Z_{st}), and peak NH_2 in the fuel-rich side. Figure 1(b) shows how the extinction probability at these three mixture fraction locations evolves over time. The maximum extinction probability at the fuel-lean side and Z_{st} occur at the same time, while the maximum on the fuel-rich side appears slightly later. Further analysis will be performed to better understanding localized extinction and reignition under the high Re condition.



(a) (b)

Fig. 1: (a) Sketch of the temporally evolving jet flame; (b) Extinction probability at different mixture fraction locations varied with time.

References

[1] S. Desai, Y.J. Kim, W. Song, M.B. Luong, F.E. Hernández Pérez, R. Sankaran, H.G. Im, Direct numerical simulations of turbulent reacting flows with shock waves and stiff chemistry using many-core/GPU acceleration, Comput Fluids 215 (2021) 104787.
[2] H. Tang, R. Barlow, G. Magnotti, Local extinction in piloted turbulent partially premixed ammonia/hydrogen/nitrogen-air jet flames, Proc. Combust. Inst. 40 (2024) 105472.