

Flamelet-based modeling of doubly transcritical methane/oxygen flames

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This work investigates various tabulated chemistry models to analyze the injection of liquid oxygen and liquid methane under doubly-transcritical conditions on a splitter-plate configuration which resembles a shear-coaxial injector. Such challenging conditions have been investigated by Monnier et al. [1] using highly-resolved “DNS-like” simulations highlighting a complex and multi-regime flame structure and preliminary modeled in Large Eddy Simulations with computationally expensive finite-rate approaches.

Leveraging the tabulated chemistry approach, we evaluate different flamelet-based strategies: the Steady Laminar Flamelet Model, the Flamelet Progress Variable approach, the Flamelet Generated Manifold and the F-TACLES [2] model within an OpenFOAM framework with a consistent formulation of the real-fluid thermodynamics [3]. To the best of the author’s knowledge, this is the first implementation of the F-TACLES model in a high-pressure supercritical context.

We compare the flame structure obtained using these different models, targeting the results provided by Monnier et al. [1], providing insights into their relative accuracy to establish a robust framework for 3D simulations of liquid rocket engine combustion chambers.

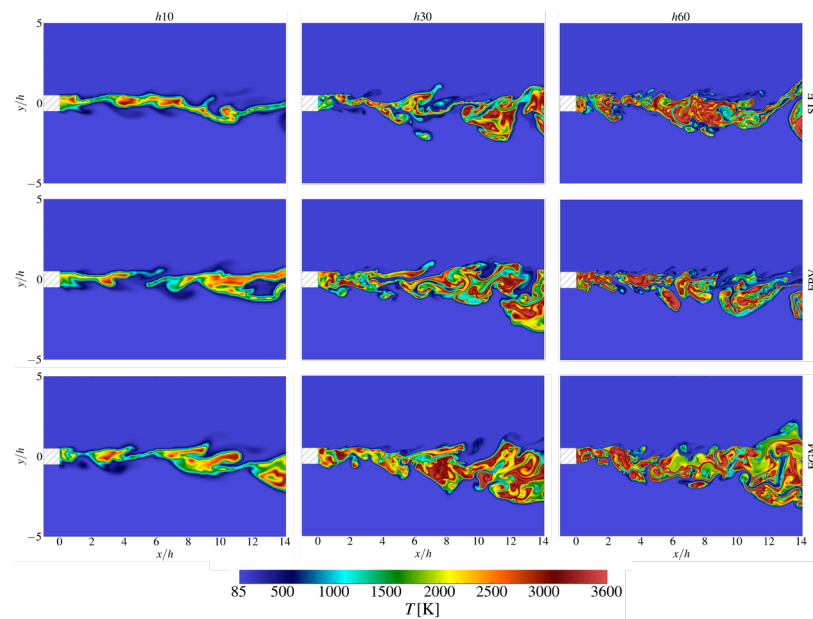


Figure 1: temperature flow-field for three flamelet models at three grid resolutions. Pressure is 100bar, while oxygen and methane are injected respectively at 85K and 120K.

References

- [1] Monnier, F. et al., Proceedings of the Combustion Institute, 2024.
- [2] Samuel, D. et al., Proceedings of the Combustion Institute, 2024.
- [3] Cavalieri, D. et al., International Journal of Heat and Mass Transfer, Under review.