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Influence of Low-Temperature Chemistry Modelling in a Ducted Rocket Combustor at Different Equivalence Ratios

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In a ramjet combustor, the modelling of the ignition delay time needs to be accurate over a wide range of temperatures and pressures in order to accurately capture the position and anchoring points of a flame. This study investigates numerically a research ramjet combustor from ONERA [1]. The combustor can be operated with both liquid fuel, or as is used here, using gaseous propane (C_3H_8), simulating a pre-vaporized solid fuel. LES computations of the reactive flow in the combustor at $0.35 \leq \phi \leq 0.75$, using the PaSR turbulence-chemistry interaction model, together with either a reduced 87-step [2] or a detailed 270-step [3] chemistry schemes for propane-air combustion, are performed. A previous study, at ϕ=0.5, concluded that it is essential to include low-temperature chemistry modelling to accurately capture flame dynamics and position. The present study expands this to also look at low and high-speed cases, corresponding to cases with a lower (ϕ=0.35) and a higher (ϕ=0.75) equivalence ratio, respectively. Emphasis is placed on the difference in LES results from the two different reaction mechanisms and how the differences in the modelling of chemical complexities affects the simulation results. Figure 1 displays instantaneous images of the combustor, at ϕ=0.5, using the 87-step reaction mechanism. Early results indicate large differences depending on which equivalence ratio is used, minor differences between the two reaction mechanisms, and reaffirm the importance of low-temperature chemistry modelling on the flame dynamics.

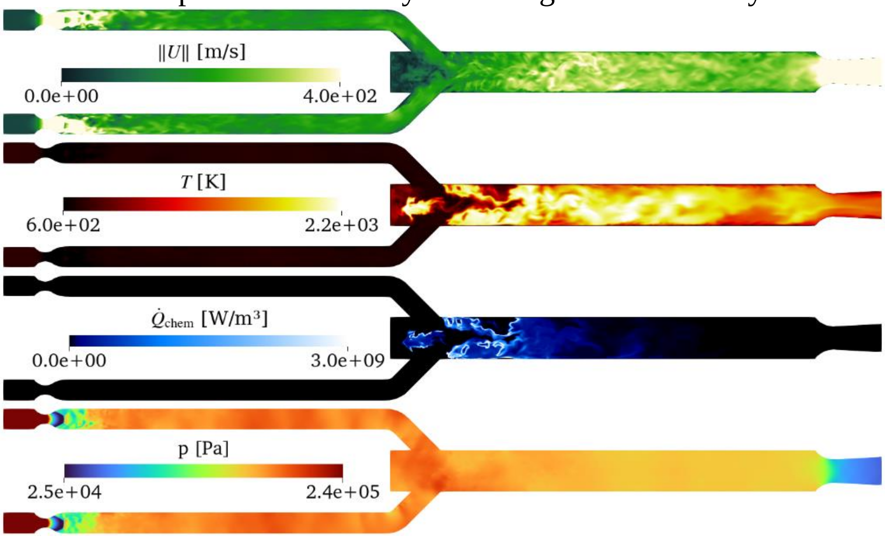

Figure 1. Sample instantaneous simulation fields on combustor center-plane computed for ϕ=0.5 using 87-step reaction mechanism. (a) velocity magnitude, (b) temperature, (c) chemical heat release, (d) pressure.

References

[1] Ristori, A., Heid, G., Brossard, C., & Bresson, A. Characterization of the reacting two-phase flow inside a research ramjet combustor. ONERA; 2003.
[2] N. Zettervall, C. Ibron and K. Nordin-Bates. Influence of low-temperature chemistry modelling on flame characteristics in a ducted rocket combustor. In ICCFD, Kobe, Japan; 2024.
[3] http://combustion.ucsd.edu [Internet]. 'Chemical-Kinetic Mechanisms for Combustion Applications', San Diego Mechanism web page, Mechanical and Aerospace Engineering (Combustion Research), University of California at San Diego.