



Adaptive Mesh Refinement-Based Grid Optimization for the AFRL Methane-Oxygen Rotating Detonation Rocket Engine

Megan Powers^{1*}, Shivank Sharma¹, Venkat Raman¹

*Lead presenter: powerm@umich.edu

¹ University of Michigan, USA

The simulation of continuous detonation combustors has posed a considerable challenge due to the presence of unsteady propellant mixing, moving shock-reaction complex, and geometric complexity introduced by the flow configuration. While many simulations of annular rotating detonation engines (RDEs) are beginning to emerge [1-5], their predictive accuracy is highly system-dependent, and reliant on the accuracy of the numerics. In order to understand the relative role of the numerical approach, and the sensitivity of the configuration to errors in modeling, a canonical RDE designed for rocket applications is studied. Extensive experimental data exists for this geometry [6]. Two different flow conditions, corresponding to baseline and high mass flow, are considered. It is known that as the mass flow rate through the system increases, the wave structure changes, with more waves observed. Here, the effect of the numerical grid, the choice of boundary conditions, and the impact of local resolution of the detonation wave on predictive accuracy are studied. Preliminary studies show that for the baseline case, the number of waves and the wave speeds are predicted with high accuracy, but the pressure distribution shows nearly 20% error. Additional studies are being conducted to determine the pathways to improving pressure predictions, including the role of injector losses on the obtained plenum and combustor pressure.

References

- [1] Pal P, Demir S, Som S. Numerical analysis of combustion dynamics in a full-scale rotating detonation rocket engine using large eddy simulations. *Journal of Energy Resources Technology*. 2023;145(2):021702.
- [2] Strakey P, Ferguson DH. Validation of a computational fluid dynamics model of a methane-oxygen rotating detonation engine. In: *AIAA SciTech 2022 Forum*; 2022. p. 1113.
- [3] Prakash S. Computational modeling of non-idealities in gaseous and multiphase detonating flows [PhD thesis]. University of Michigan; 2022.
- [4] Schau KA, Oefelein JC. Numerical analysis of wave characteristics in a methane-oxygen rotating detonation engine. *AIAA Journal*. 2023;61(1):97–111.
- [5] Ross M, Burr JR, Harvazinski ME. Relating high-fidelity RDRE simulations to thermodynamic cycles, using fluid trajectories. In: *AIAA SciTech 2024 Forum*; 2024. p. 2036.
- [6] Bennewitz JW, Burr JR, Bigler BR, Burke RF, Lemcherfi A, Mundt T, Rezzag T, Plaehn EW, Sosa J, Walters IV, et al. Experimental validation of rotating detonation for rocket propulsion. *Scientific Reports*. 2023;13(1):14204.