

Large Eddy Simulation of Reacting Solid Rocket Motor Plumes Containing Particles

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The use of Large Eddy Simulations (LES) in the modelling of Solid Rocket Motor (SRM) plumes has been applied for decades. Level of sophistication has gradually increased from incompressible and inert descriptions of the gas flow [1, 2], to today's level where, finite rate descriptions of the chemical kinetics interact with highly resolved compressible flow structures [3]. In this work, reacting LES's of two static SRM at sea-level atmospheric conditions are performed in order to explore the methods viability as a method to predict the infrared signature of SRM plumes. The two different SRMs differ mainly in their propellant, where the first (case 1) results in no condensed exhaust products whereas the second (case 2) produces larger amounts of condensed alumina. The LES was performed using an in-house developed solver called *explicitReactingFoam*, based on the OpenFOAM-7 code library. This solver is a second-order conservative multi-species explicit density-based solver. Formation and destruction rates of molecular species were governed by a reaction mechanism with 39 reactions, developed for this study. To account for alumina, a Lagrangian Particle Tracking approach was used to model the particles and their effect on the flow. Figure 1 shows preliminary results from the simulation where post-combustion, critical to infrared signature prediction, of the rocket exhaust are evident, driven by mixing between plumes and surrounding air.

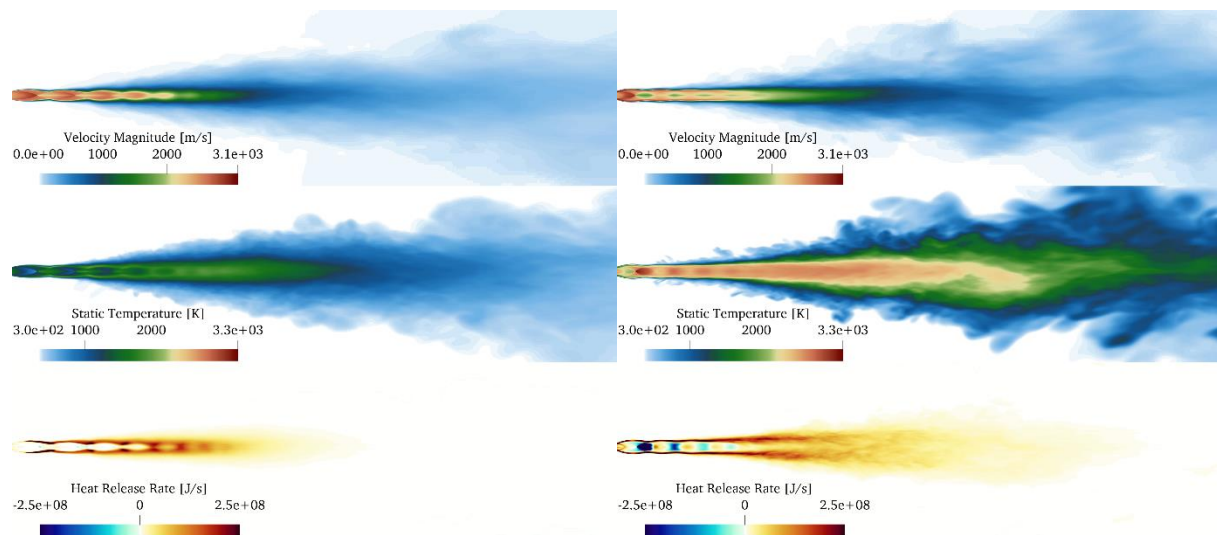


Figure 1. Time-averaged (at the moment of writing) gas properties of the plumes viewed through a vertical cut plan (case 1 on the left and case 2 on the right), a) velocity magnitude, b) static temperature and c) volumetric chemical heat release.

References

- [1] Moser, R., et al. "Simulating flows in solid rockets." 30th Fluid Dynamics Conference. 1999.
- [2] Berglund, Magnus, and Christer Fureby. "Large eddy simulation of the flow in a solid rocket motor." 39th Aerospace Sciences Meeting and Exhibit. 2001.
- [3] Paoli, Roberto, Adèle Poubeau, and Daniel Cariolle. "Large-eddy simulations of a reactive solid rocket motor plume." *AIAA Journal* 58.4 (2020): 1639-1656.