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Numerical simulations of mixing under supercritical pressures of a shear coaxial injector using a high-order method: effect of outer jet temperature

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Understanding the mixing and combustion processes under supercritical pressures is of great importance for the improved prediction of rocket combustor performance. The present study aims at numerically investigating the high pressure mixing of the cryogenic nitrogen and hydrogen injected from a shear coaxial injector. The primary interest lies in the effect of the outer jet temperature on the mixing dynamics.

The numerical method consists of the mass, momentum, pressure evolution, and species-mass equations, which are solved using a 6th-order compact differencing and a 3rd-order TVD Runge-Kutta schemes. The Soave-Redlich-Kwong (SRK) equation of state is applied. The physically-consistent numerical diffusion terms, which maintain the velocity and pressure equilibriums at inviscid interface, are introduced to prevent possible spurious oscillations [1].

A preliminary result is shown here. The conditions used so far are listed in Table. 1, where the pressure is set to 10 MPa for each case. The density (temperature) and velocity are chosen so that the same mixture ratio of about 6 is satisfied. Figure 1 shows the instantaneous flow filed for each case, in which the iso-surface of density (a half value between the jet and chamber) and the mass fraction of hydrogen jet are presented. In spite of the same mixture ratio, the dense core of nitrogen jet in case 1 is much shorter that in case 2, indicating that the warmer/ligher outer jet with larger velocity may achieve a higher mixing performance, while the dense core of nitrogen jet clearly remains in the downstream region with the colder/heavier outer jet. More detailed discussion about the flow fields, while adding other conditions, will be made in a final paper.

Table 1 Computational conditions

Case	Inner jet (N_2)	Chamber (N_2)	Outer jet (H_2)
1	96.6 K, 750 kg/m^3, 15 m/s	810 K, 40 kg/m^3	461.7 K, 5 kg/m^3, 200 m/s
2			51.7K, 50 kg/m^3, 20 m/s

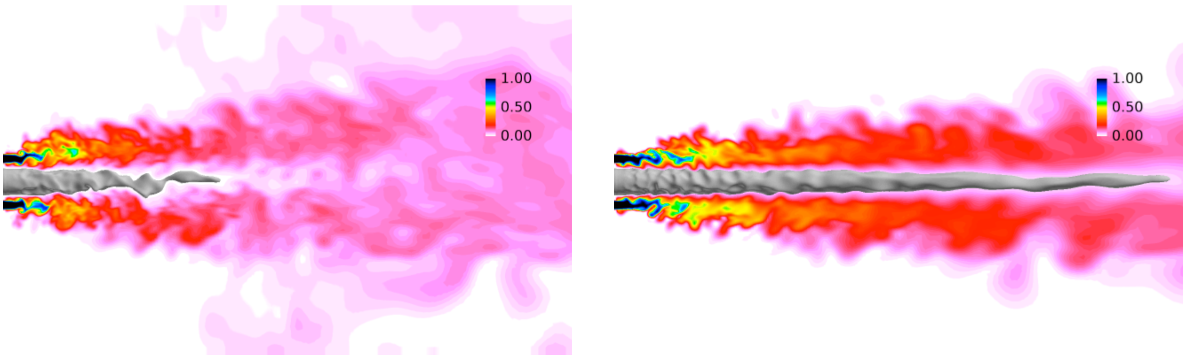

Figure 1 Instantaneous flow fields near the coaxial injector (left: case 1, right: case 2)

[1] H. Terashima and M. Koshi., “Approach for simulating gas-liquid-like flows under supercritical pressures using a high-order central differencing scheme,” Journal of Computational Physics, **231** (20), 2012, pp. 6907-6923.