Numerical Stdudy of MMH/NTO Hypergolic Ignition in Co-flowing Plane Jets

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Abstracts

This study is a numerical analysis of hypergolic ignition of MMH(monomethylhydrazine)/ NTO(nitrogen tetroxide) for application to a 10 N storage bi-propellant thrusters developed in Korea. MMH and NTO are bipropellants with high specific impulses, which allows for a significant reduction in propellant weight. They are commonly used in upper-stage engines, satellite orbit insertion, and attitude control thrusters, due to their ability to remain in a liquid state in extremely low-temperature environments such as space.

In order to numerically analyze the combustion process of these bi-propellants, a reaction mechanism is required to calculate the chemical reaction between the fuel and the oxidizer. The reaction mechanisms used in this study are a newly developed reduced mechanism with 31 species and 29 reactions. The hypergolic ignition process was confirmed by spraying gaseous MMH and NTO in coaxial jet flows.

Simulation domain, initial and boundary conditions were composed by referring to Tani's CFD simulation results [1]. The grid was created in the form of two-dimensional co-flowing plane jets instead of coaxial jets, and the number of cells was 0.15 M. As initial conditions, the mole fraction of fuel was set to 0.5, the oxidizer was set to the mole fraction of N2O4 is 0.325 and N2O is 0.175, and the internal field was set to AR as a noble gas. The initial temperature of the fuel, oxidizer and internal field is 293 K. The velocity of the fuel was fixed at 50 m/s and the velocity of the oxidizer was changed to 30, 50, 70 m/s and the results were compared.

The HONO production reaction releases a large amount of heat and accelerates the temperature rise of the gas mixture, resulting in autoignition. It was confirmed that the concentration of HONO at the interface before ignition was high, and from the region of 1400 K or higher, HONO was decomposed and the reaction of CH4-O2 mainly occurred, raising the flame to the maximum temperature.

References

[1] Tani H, Terashima H, Kosh M, Daimon Y. (2015). Hypergolic ignition and flame structures of hydrazine/nitrogen tetroxide co-flowing plane jets. Proc. Combust. Inst. 35: 2199.

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