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SECONDARY COMBUSTION IN STAGED HYBRID ROCKET ENGINE

Abstract

Staged hybrid rocket engine (HRE) is a concept which minimizes the performance variation with respect to O/F shifting, while maintaining the key advantages of HRE. It uses a hybrid gas generator(GG), as a primary combustor, which utilizes solid fuel and liquid oxidizer to produce fuel-rich effluent, which is then expelled and mixed with additionally aft-injected oxidizer in the secondary combustor for a stoichiometric combustion.

A key component of a staged HRE is the secondary combustion, and this has been the focus of present paper. In order to maximize the combustion performance, it is vital to have a good oxidizer/effluent mixing and therefore studying of this mixing characteristic is essential. Also, to maximize the benefit of experimental tests, it is necessary to choose and narrow down a test matrix that would likely perform a good combustion performance. Therefore, the sensitivity of configurations and flow conditions, including inlet angles, inlet diameters, and O/F momentum ratio, on mixing and combustion performances should be firstly investigated.

The chosen methodology is two-dimensional reacting flow computational fluid dynamics (CFD) modeling with a probability density function combustion model. A key advantage of CFD modeling is that, it is possible to evaluate a wide range of configurations and flow conditions on combustion performance, which may be very difficult to be designed and performed in real combustion test. To evaluate the combustion performance, efficiency based on temperature rise was used for both CFD and experimental results. HTPB with 28% oxygen/72% nitrogen mixture oxidizer (O/F of 2.5) was used to simulate the effluent, which was reported to be the optimal formulation in hybrid GG of staged HRE. As for the oxidizer, gaseous oxygen was used. For all modeling, measured data from the combustion tests were used to set boundary conditions as realistic as possible. To validate the CFD code, ramjet combustor configuration used by Chao, is adopted in this study. And, the present methodology of turbulent reacting flow is satisfactory with respect to data reported.

With use of CFD modeling, it would be possible to evaluate the combustion performance differences of various configurations and flow conditions. Hence, a wide range of case study is planned to be performed with a goal to analyze and estimate the combustion performance. Then, a test matrix will be carefully chosen for the experimental test for validation purpose. Finally, based on results, the optimal configuration and flow condition of secondary combustion will be presented.