Paper ID: 23424
student

SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (1) (3)

Author: Ms. Jinhui Yang
Beihang University, China

Dr. Yue HAN
China Eastern Airlines Corporation Limited, China
Mr. Nanjia Yu
Beijing University of Aeronautics and Astronautics (BUAA), China
Mr. Jian Dai
China
Prof. Guobiao Cai
Beijing University of Aeronautics and Astronautics (BUAA), China

EXPERIMENTAL AND NUMERICAL STUDY OF FLAME STRUCTURE AND COMBUSTION DYNAMICS IN A SHEAR COAXIAL INJECTOR WITH GH2/GO2

Abstract

The reusable launch vehicle (RLV) has gained increasing attention in the field of astronautics technology over the past decades due to its low cost and high reliability. As the new generation of RLV engine, the full flow stage combustion cycle (FFSC) engine has been developed owing to its optimal performance. Since the gas-gas injector plays a critical role in the FFSC engines, the combustion performance of a shear coaxial injector with gas hydrogen/gas oxygen (GH2/GO2) is investigated theoretically, numerically and experimentally in the present study. Based on the theory of similarity of gas-gas combustion, the similarity criteria are established and a scaled model of space shuttle main engine (SSME) is designed for research purpose. Various operating conditions are tested by varying the velocity ratio (VR) of fuel to oxidizer and the propellant mixing ratio (MR) as two main parameters in order to assess their impacts on the combustion behavior inside the combustion chamber equipped with the shear coaxial injector. Joint-optical diagnostic techniques are employed, including Planar Laser-induced Fluorescence on OH radicals (OH-PLIF), high-speed imaging and infrared thermography. From the OH-PLIF measurements, flame fronts can be extracted and mean reaction zones (MRZ) can be calculated. High-speed imaging is performed to reveal the ignition process and help to identify the combustion-induced instabilities; the combustion dynamics is explored in form of Campbell diagram. Flame lengths, temperature distributions and heat fluxes are discussed experimentally by means of infrared thermography. A numerically-aided approach using Reynolds-averaged Navier-Stokes (RANS) simulation is proposed to complete the experimental analysis. Numerical and experimental results on MRZs and flame lengths are proved to be mutually supportive and thus validate each other. Complementary information provided by the numerical simulations serves to correlate the experimentally acquired distributions of OH concentration with physical OH molecule density, which extends the qualitative measurements to highly quantitative comparison and enables the exploration of the insights into flame structure and combustion mechanism. This study is a first attempt to establish a standard OH-PLIF database of GH2/GO2 combustion which is typical in the space propulsion. The results and discussion are able to provide guidelines for design and optimization of both SSME and liquid rocket engine using FFSC technology.