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FLAME INITIATION INSIDE THE GAS TORCH IGNITION SYSTEM FOR A HYBRID ROCKET MOTOR

Abstract

The Chemical Propulsion Laboratory of the University of Brasilia has successfully designed, manufactured and tested the prototype of a torch ignition system for a hybrid rocket motor. The ignition system working on GOx/GCH4 is capable of generating a wide range of power and oxidizer-to-fuel ratios. It has self-cooled vortex combustion chamber with one fuel jet injector and one circumferential vortex oxidizer injector. Thus, the flow is oxidizer-rich near the wall protecting it from overheating and fuel-rich in the axis of the chamber. The ignition system is controlled by the temperature and pressure sensors, adjusting the mass flow rates of the propellants through the control valves and organizing cooling of the wall and flame stabilization. Thus, operation of the ignition system is predictable and reliable. Current work is devoted to the study of combustion initiation inside the igniter from the spark plug discharge mounted on the wall of the igniter's combustion chamber.

Theoretical research on methane-oxygen flammability allowed to estimate favorable ignition conditions and to define the corresponding propellants mass flow rates and equivalence ratios.

Experimental analysis on the ignition limits was made on the laboratory test bench. The ignition system was assembled with the hybrid rocket motor combustion chamber in order to repeat its design operational conditions. The propellants pressure and mass-flow rates, combustion temperature, ignition delay and the spark frequency were controlled during the tests. Many tests were executed with different combinations of the propellants mass flow rates. As a result, the region of stable ignition was found, as well as the regions of ignition failure or unreliable ignition. Comparison of the experimental data with the theoretical results showed acceptable correlation.

Previously validated numerical model was used for the detailed analysis of the flow in region of the reliable ignition and also in a region of the ignition failures. Several numerical simulations of the transient three-dimensional chemically reacting flow were realized. As a result, the ignition delay and the thermal impact on the combustion chamber wall were determined numerically. Results of the simulations were compared with theoretical and experimental data showing good correspondence.

Current studies allowed to determine experimentally the ignition limits of methane-oxygen mixture inside the vortex combustion chamber and to elaborate a reliable ignition algorithm. At the present time,

the ignition system is being used in the test motors of the Laboratory: solid ramjet motor, liquid ramjet motor and hybrid rocket motor.