IAF SPACE PROPULSION SYMPOSIUM (C4)
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A STUDY ON THROTTLING, ANTI-O/F SHIFT OPERATION AND LOX VAPORIZATION FOR HYBRID ROCKET ENGINE WITH MULTI-SECTION SWIRL INJECTION METHOD

Abstract

The authors have proposed a new combustion method which can increase fuel regression rate. The new method is named as Multi-Section Swirl Injection Method, which generates swirling flows at some cross-sections in combustion chamber. The method is quite powerful to increase fuel regression rate by 3 to 8 times compared with that of conventional method. In the present study, paraffin fuel with lower melting point and oxygen gas are selected as propellant. Oxygen gas will be replaced by liquid oxygen for real flight. To realize Multi-Section Swirl Injection Method for real flight, module-type engine structure, in which swirl oxygen injection is attached at upstream end of each module to introduce swirl flow in combustion chamber, has been proposed. By combining those module-type engine we could keep swirl injection throughout combustion chamber. However, in this method O/F shift occurs during combustion because inner radius of fuel increases and mass flow rate increases. In order to overcome this O/F shift, mass flow control of oxidizer should be controlled during combustion. In the present study oxidizer is supplied not only at each front end of the combustion module but also in axial direction from upstream end of combustion chamber. This method is called as A-SOFT method. In the present study another circular injection of oxidizer is supplied at the mixing chamber, which is located at the end of the combustion chamber. The purpose of the injection is to provide oxidizer to unburned gas without increasing fuel regression rate directly. Additional oxidizer injections at the end of combustion chamber works quite good and almost constant O/F values are kept constant during combustion and increase of thrust is realized. By using the same system throttling capability of the system has been proved. Also, vaporization of liquid oxygen is one of the key technology to realize swirl injection for higher fuel regression rate. Pressured LOX is spread out through special spray nozzle and small particles of liquid oxygen are injected into vaporization chamber. In the vaporization chamber hot gas, which is obtained from pre-burner of small hybrid rocket engine, is injected into those small particles of LOX. Almost all the small particles of LOX are vaporized and gaseous oxygen are sent to main combustion chamber to realize A-SOFT Multi-Section swirl injection method. In the present study a whole system starting from LOX tank to combustion chamber of A-SOFT Multi-Section swirl injection method.