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PERFORMANCE CALCULATIONS AND BURNING TESTS ON ALTERING-INTENSITY SWIRLING OXIDIZER FLOW TYPE HYBRID ROCKET ENGINES

Abstract

In this presentation, as a promising candidate of high functional hybrid rocket engine which combines throttling and long time burning without O/F shift, high regression rate and low cost, Altering-intensity Swirling Oxidizer Flow Type (A-SOFT) hybrid rocket engine is proposed and the results of flight performance simulations and burning tests are presented.

In practical usage of conventional hybrid rocket engines, O/F shift happens along fuel port diameter increase and throttling because fuel regression rate is not proportional to oxidizer mass flux. Engine performance losses caused by O/F shift are still controversial because there is no performance evaluation including all considerable phenomena dependent on O/F shift and affecting total impulse of hybrids. A representative unconsidered phenomena is carbon nozzle throat erosion, which is affected by oxidizer rich burned gas by O/F shift. Another one is the change of c* efficiency by O/F shift, throttling, port diameter increase, nozzle erosion rate.

In A-SOFTs, the dependence of fuel regression rate on oxidizer swirl intensity is applied to cancel O/F shifts independently of oxidizer mass flow rate. In order to control both oxidizer swirl intensity and total mass flow rate, oxidizer feed line splits into two branches and they are respectively connected to axial and tangential injectors. Mass flow rates in these branches are controlled independently with two control valves. Oxidizer mass flow ratio of the two branches is the control variable of swirl intensity.

In this presentation, first of all, several sets of A-SOFT and SOFT sounding rocket flight performances are simulated and the difference of the performances is discussed. In these simulations, the solution of Goddard problem is used to calculate thrust curves. These calculations include a nozzle throat erosion model based on the evaluation of molecular fluxes of CO2 and H2O into carbon nozzle throat and a c* efficiency model based on L* theory besides solid fuel regression model of A-SOFTs, chemical equilibrium model and 1-dimentional ideal nozzle model.

Secondly, the results of two sets of burning tests of a lab-scale A-SOFT engine are presented. The purposes for these tests are to show regression rates of A-SOFTs depend on total oxidizer mass flow ratio of axial and tangential injectors and to acquire actual regression rates data in several mass flow ratio or port diameter conditions.

Finally, this presentation ends with the summary of these works and a future plan for thrust and O/F feedback control tests of the lab-scale A-SOFT engine.