SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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DEVELOPMENT OF HIGH PERFORMANCE HYBRID ROCKET ENGINE WITH MULTI-SECTION SWIRL INJECTION METHOD FOR SPACE PROPULSION SYSTEM

Abstract

Hybrid rocket is one of the promising space propulsion systems with a lot of advantages such as safety, low cost, throttling of thrust, re-ignition, and nontoxic and nonhazardous propellant. However it also has disadvantages of low fuel regression rate and low combustion efficiency. The authors have proposed a new combustion method which can improve the fuel regression rate more than that of conventional method. The new method is named as Multi-Section Swirl Injection Method, which generates swirling flows at some cross-sections in combustion chamber. In the present study, high density polyethylene fuel and paraffin fuel with oxygen gas are used. Various improvements have been conducted in order to improve performance of the engine with standpoint of 1) effects of location of injector section in axial direction, 2) effect of interaction of injected oxygen gas with others, 3) effects of multi-port system, 4) effect of direction of swirl flow (i.e. combination of clockwise and counter-clockwise swirl), 4) optimum relationship between port diameter and length of grain and etc. For high density polyethylene fuels the fuel regression rate with multi-section swirl injection method shows about 2.3 times higher than that of the conventional no-swirl injection method. For multi-port system, 4, 5, and 7 ports system have been investigated and about 4 times higher mass reduction rate have been realized. For paraffin fuels the fuel regression rate with multi-section swirl injection method shows about 3 to 10 times higher than that of the conventional no-swirl injection method. One of the significant results is obtained for combination of clockwise and counter-clockwise swirl injection. Interacting flows at intersection of two circulating flows with different direction increase turbulent mixing during combustion and the results improve c* efficiency significantly. Also, combustion flames of multi-section swirl injection method have been newly observed through upstream quartz glass window. The results show the injected oxygen gas flows along the surface of the fuel and keeps strong swirling flows inside combustion chamber. Those results show the new method

of multi-section swirl injection is quite useful and is proved to be one of the powerful propulsion system for low cost and high performance space propulsion system.