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INVESTIGATION ON PERFORMANCE IMPROVEMENT OF THE NEW HYDROGEN PEROXIDE THRUSTER WITH EXTERNALLY HEATED AEROSPIKE NOZZLE

Abstract

Aerospike nozzles can achieve high performance regardless of altitude because the nozzle outlet flow is optimized according to the external pressure, but there is a cooling problem. 90% hydrogen peroxide has a low decomposition gas temperature of about 800C, so if applied to aerospike nozzles, the cooling problem can be avoided. In addition, because the aerospike nozzle can be easily heated by such as an external laser or other means due to its shape, it is expected to improve performance due to the increase in nozzle surface pressure, associated with the heating.

To confirm the feasibility of this new concept combining hydrogen peroxide, an aerospike nozzle, and external heating, we first examined the use of air as the propellant. The nozzle wall was set to high temperature conditions, and a three-dimensional cake-cut model steady-state CFD analysis was performed by applying the k-ω SST model. As a result, it was confirmed that the nozzle flow heating improved the thrust and specific impulse by approximately 2%. Next, a similar analysis was performed using hydrogen peroxide decomposition gas as propellant, however, the performance improvement was only about 0.02%. The analysis showed that the reason for the small improvement was thought to be that the heat flux of hydrogen peroxide decomposition gas, which has a small temperature difference from the nozzle wall, is much smaller than that of room temperature air, which has a large temperature difference from the nozzle wall, resulting in a small temperature increase. Therefore, efficient heating of the high-temperature nozzle gas flow is essential for significant performance improvement in this new thruster concept.

Therefore, we attempted to improve the nozzle flow heating effect by changing the nozzle shape and heating method. It was confirmed that the effect of the heat transfer enhancement by the nozzle geometry change can recover the thrust increase effect to the level of 0.1% or more, but at the same time, it was found to be difficult to improve the effect by several percent level. On the other hand, when an analysis simulating the heating of the nozzle flow by plasma is performed, which is the basic idea of this concept and assumes external heating by a laser or other electromagnetic waves, it is revealed that thrust and specific impulse increase of several % or more is possible.