Paper ID: 16526
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SPACE PROPULSION SYMPOSIUM (C4)
Poster Session (P)

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DESIGN AND SIMULATION OF GAS OXYGEN / METHANE VORTEX COOLING THRUST CHAMBER

Abstract

Currently, the vortex cooling technology has gained wide attention as a new type of thrust chamber cooling method for liquid rocket engine in the world. Using tangential oxidant injection in the thrust chamber forms dual vortex structure, thereby limits the combustion zone and avoids the sidewall temperature rise. The technology can effectively simplify the thrust chamber structure, reduce costs and increase system reliability. It is especially promising in the tiny thrust engine. Compared with hydrogen, methane has better storability characteristics and higher density specific impulse. It can be used in a variety of space missions and planetary vehicles. In this paper, a preliminary design of 300N gas oxygen / methane vortex cooling thrust chamber is performed. The influence of the fuel injection methods and the configurations of the thrust chamber on improving heat distribution of head-panel is mainly investigated. Adopting RNG k-ε turbulence model and PDF non-premixed combustion model, Fluent 6.3 commercial software was used to simulate the flow field of thrust chamber for sphere-head thrust chamber, extended thrust chamber, variety of fuel injection methods (axial, radial and tangential) and their combinations. Thrust chamber performance and the cooling wall effect of these designs were compared, and the influence of thrust chamber aspect ratio, contraction ratio and gas oxygen swirl velocity on specific impulse performance, thermal load of the head and side wall was analyzed in order to increase specific impulse performance and improve the heat transfer behavior of thrust chamber. The results showed that the combustion in the thrust chamber was stable. The extended thrust chamber can effectively reduce the sidewall temperature rise under a small mixing ratio (oxygen fuel ratio 2.5-3.3). The heat load of head-panel is significantly affected by the fuel injection method and head structure. The sphere head is helpful to avoid head high temperature. Radial and tangential fuel injection would help to improve propellant mixing and increase combustion efficiency. Combustion efficiency is increased dramatically with the swirl velocity increase of gaseous oxygen. In the simulation conditions, it appears that optimum aspect ratio and contraction ratio exists when considering both specific impulse performance and head, sidewall temperature rise.