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SIMULATION OF THE VORTEX-COOLED THRUST CHAMBER BASED ON GASEOUS OXYGEN AND KEROSENE

Abstract

Vortex-cooling is an advanced thermal protection technology applied in thrust chamber, inside that dual swirl flow structure can be formed to organizing combustion. The mixing and combustion of the bipropellant are limit in the central zone. Thus the external vortex prevents high-temperature gas from transferring heat to chamber wall so that the heat load and temperature on inner wall surface are reduced. The vortex-cooled thrust chamber has numerous advantages, such as high performance, simplified construction, low manufacturing cost, easy maintenance and repeatability. With the development of non-toxic and green propellant, LOX/hydrocarbon combination has been bestially concerned and kerosene has been widely utilized in many space activities. As a common type of engine, GOX/RP-1 thrust chamber has been studied for many years and has overcome a series of key technologies, but currently wall cooling, kerosene deposit and low efficiency of small thrust engine has been not solved better yet. Then the vortex-cooled thrust chamber can effectively eliminate frontal problems. At present the research on vortex-cooling technology mainly focuses on gas/gas or liquid/liquid propellant combinations, however rarely aims at gas/liquid vortex. Compared with the former, the latter's atomization, mixing and combustion are more complicated. Aiming at GOX/RP-1 vortex-cooled technology, a new chamber was designed and hot numerical simulation was carried out in order to understand mechanism and sensitive factors. It's concluded that internal and external flow structure exists in chamber and internal swirl region occupies 87.8% chamber diameter, which is relatively wider than gas/gas vortex-cooled chamber. Moreover the flow structure in chamber is sensitive to injection velocity, spray angle and injection position. It's found that the recirculation zone near chamber head is profitable to mixing, combustion, flame stabilizing and efficiency improving, while residence time of hot gas is extended that will result in a relatively higher temperature there. The centrifugal force functioning on fuel produced by tangential velocity of oxidant extremely affects droplet's motion. Finally chemical reaction emerges in an annular zone from 39% to 81% chamber diameter and combustion efficiency can be raised through adding secondary oxidant injection in the center of chamber.