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超燃冲压发动机燃烧室的燃烧特性

Combustion characteristics of scramjet combustor

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中文摘要:

以一种低内阻光滑通道煤油超燃冲压发动机燃烧室为应用背景，采用有限差分法对燃烧室超声速流场进行了数值模拟.对流项采用3阶WENO（weighted essentially non-oscillatory）格式，湍流模型为SST（shear stress transport） k-ω模型，煤油（$C_{12}H_{23}$）/空气反应模型采用单步化学动力学模型.将燃烧室中沿侧壁的壁面静压的计算结果与实验结果进行了对比，结果符合良好，说明该算法适用于煤油超燃燃烧室计算. 研究了燃烧室来流静温、燃料/空气当量比和射流位置对煤油超声速流动与燃烧的影响.计算结果表明：燃烧集中在安装喷嘴一侧的壁面边界层附近，点火位置对当地静温非常敏感.随着来流静温降低、燃料/空气当量比减小和燃烧室扩张角增大，燃烧效率降低，燃烧性能下降，点火位置逐渐向燃烧室出口移动，燃烧放热形成的激波串结构消失.在燃烧室上、下壁面交错布置燃料喷嘴有利于提高燃烧效率.基于此，初步获得了光滑通道燃烧室内煤油点火燃烧的临界条件.

英文摘要:

Based on a kind of kerosene-fueled scramjet combustor with low internal drag slick configuration, numerical simulation based on finite difference method was performed for its supersonic flowfield. The inviscid flux was discretized by WENO (weighted essentially non-oscillatory) scheme, and the turbulent model was SST (shear stress transport) k-ω model. The single step chemical reaction mechanism was adopted for kerosene ($C_{12}H_{23}$). Predicted value of the wall static pressure along the side wall of the combustor is consistent with previously reported test data, indicating the present algorithm is applicable for the simulation of supersonic combustion in kerosene-fueled combustor. The effects of inflow static temperature, fuel/air equivalence ratio and jet location on the kerosene supersonic flow and combustion in this combustor were discussed. Results show that combustion is concentrated near the wall boundary layer at the side of the jet nozzle, and the ignition location is very sensitive to the local static temperature. The lower inflow static temperature, fuel/air equivalence ratio and the larger combustor expansion angle mean the less combustion efficiency and combustion performance, and the ignition location moves towards the combustor exit, with the shock cluster inspired by combustion disappearing. Staggered arrangement of the jet nozzles on the upper and lower walls of the combustor can improve the combustion efficiency. Therefore, preliminary critical boundary conditions are obtained to achieve ignition in the slick kerosene-fueled combustor.

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