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激光功率和工质对连续激光推力器性能影响的数值模拟

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Numerical Simulation for Impact of Laser Power and Propellant on Performance of Continuous-wave Laser- sustained Plasma Thruster

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摘要 对连续激光维持的等离子体加热推力器内流场建立一种计算模型,考虑的物理机制包括化学反应、高温气体性质、激光吸收、黏性、扩散、热传导以及辐射效应,模型方程形式为可压缩轴对称Navier-Stokes方程,对方程采用SIMPLEC算法求解。在吸收室压强、聚焦光束形状参数及喷管构型相同的条件下,模拟了氩为工质的推力器比冲随激光束功率变化和氢为工质的推力器比冲随喷管喉部半径的变化情况。研究结果表明:由于热物理性质不同,氢为工质的推力器具有更高性能;较小的推力器内部流道可提高工质比焓和加热均匀性,能够获得更大比冲。

关键词: 连续激光 推进 氩 氢 激光维持等离子体 数值模拟

Abstract: A numerical model is established for a continuous-wave laser-sustained plasma thruster which takes into consideration the chemical reactions, high-temperature thermodynamic properties, viscosity, diffusion, heat conduction and the effect of radiation on the thruster. The compressible axisymmetric Navier-Stokes equations are solved by pressure-based SIMPLEC algorithm. Given the same chamber pressure, beam focusing geometry and nozzle configuration, the specific impulses with argon propellant for different laser powers are calculated, as well as those with hydrogen for different throat radii. The results indicate that thruster with hydrogen has a better performance due to its intrinsic properties, and that properly reducing the thruster internal space can increase the specific enthalpy and heat uniformity of the propellant, thus improving the specific impulse.

Keywords: continuous-wave laser propulsion argon hydrogen laser-sustained plasma numerical simulation

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