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微推进系统中微型喷嘴结构参数的实验研究

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Experimental Research on Structural Parameters of Micro-nozzle Applied on Micropropulsion Systems

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摘要 为了研究用于微小卫星姿态调整或轨道修正的微型喷嘴的结构参数对其推进性能的影响,采用微机电系统(MEMS)工艺加工了一系列不同结构参数的微型喷嘴,各结构参数包括半扩张角、喉口段长度、喉口宽度以及面积比。实验过程在大气环境下进行。实验发现了微型喷嘴具有与宏观尺寸喷嘴不同的性能特点,总结出了喷嘴性能随结构参数和运行工况的变化规律。实验表明:壅塞状态下,入口压力越大喷嘴的最佳半扩张角度越大;喷嘴喉口段的长度对喷嘴的性能没有明显的影响;喷嘴喉口宽度增加能使推力明显提高,但是同时使比冲持续减小;面积比越大,微喷嘴的推力越小,而面积比为5时喷嘴的比冲达到最大。本文工作对微喷嘴的设计及应用有一定的借鉴和帮助作用。

关键词: 微小卫星 微喷嘴 结构参数 性能 设计

Abstract: In order to investigate the effect of structural parameters on the thrust performance of the micro-nozzles which is used in the attitude adjustment and orbit correction for micro-satellites, micro-nozzles with different structural parameters are fabricated by microelectromechanical system (MEMS) technology. The parameters comprise the half divergence angle, length of throat section, throat width and area ratio. The experiment processed in the atmosphere environment. It is found that some features are different from those of the conventional macro-nozzles. The effects of structural parameters and operation conditions on micro-nozzle's performance are concluded. The experimental results show that: the optimal half divergence angle increase with the inlet pressure increasing in an choked flow; the length of throat section has little effect on micro-nozzle's performance; a larger throat width makes a larger thrust for the same inlet pressure, on the other hand it produces a smaller specific impulse; for the same inlet pressure, nozzle with larger area ratio produces smaller thrust, and the specific impulse comes to a maximum when the area ratio is close to five. The results of this paper will be helpful for the design and application of micro-nozzles.

Keywords: micro-satellite micro-nozzle structural parameter performance design

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