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微纳技术与精密机械

超音速共形整流罩风洞试验及其光机特性

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摘要： 研究了共形整流罩超声速飞行时气动压力对其光机特性的影响。设计了口径为203 mm,长径比为1∶1的椭球型整流罩,完成了速度为2.0、2.5及3.0 *Ma*,攻角为0°的风洞试验,获得了共形整流罩外表面压强值。建立了整流罩有限元模型,通过流固耦合仿真计算,得到材料为热压MgF_2的共形整流罩在不同厚度时的面型变化及应力分布数据,并拟合了内、外表面变形后的轮廓曲线方程。设计了光学成像质量评价光学系统,对比了共形整流罩受气动压力前后的成像质量。结果表明,共形整流罩厚度为2 mm,速度为3.0 *Ma*时可产生最大应力37.5 MPa;与整流罩面型变形前成像质量比较,点斑最大相对误差为0.26%,波面PV值最大相对误差为-1.03%。在只承受气动压力的情况下,该结果满足结构强度及光学成像质量要求,可为共形光学系统设计及优化工作提供部分依据。

关键词： 共形整流罩 气动压力 光机特性 风洞试验 流固耦合

Wind tunnel experiment of supersonic conformal dome and its optical and structure characteristics

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Abstract: The impact of pneumatic pressure for a supersonic conformal dome on optical and structure characteristics was studied. The elliptical dome with a diameter of 203 mm and the ratio of length to diameter of 1∶1 was designed. Wind tunnel experiments in an attack angle 0' were accomplished by speeds of 2.0, 2.5 and 3.0 *Ma* and the pressure was obtained on the surface of dome. The displacement distribution and the stress distribution of a hot-press MgF_2 dome were obtained by the fluid-structure coupled analysis on the finite element model based on different thicknesses. According to the data, the figure curves of these dome models were fitted renewedly. Imaging quality was compared based on the optical system designed and the results illuminate that the maximum stress is 37.5 MPa when the thickness of the dome is 2 mm and the speed is 3.0 *Ma*. At the same time, by contrast with the initial optics of the dome, the relative error of spot radius is 0.26%, and figure relative error is -1.03%, which meets the requirements of structure strength and imaging quality under the dynamic pressure.

Keywords: conformal dome pneumatic pressure optical and structure characteristics wind tunnel experiment fluid-structure coupling

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