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推力耦合的高超声速飞行器气动伺服弹性研究

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Study on Aeroservoelasticity of Hypersonic Vehicles with Thrust Coupling

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摘要 参考文献 相关文章

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摘要 对于采用吸气式超燃冲压发动机的高超声速飞行器,其发动机推力可能与机身弹性发生耦合影响,从而引起所谓的推力耦合气动伺服弹性(ASE)问题。为对其耦合原理及影响进行研究,以简化的飞行器纵向模型为对象,考虑结构弹性、非定常气动力、冲压发动机以及控制系统之间的相互耦合作用,建立了推力耦合的高超声速飞行器气动伺服弹性问题的一般建模框架和分析流程。采用牛顿冲击理论计算高超声速非定常气动力,基于准一维流动假设分析发动机性能。算例结果表明,考虑发动机推力的耦合影响后,飞行器的短周期特性和气动伺服弹性特性均有明显改变,气动伺服弹性稳定裕度下降可达16%,应当引起飞行控制系统设计部门的重视。

关键词： 高超声速飞行器 气动伺服弹性 超燃冲压发动机 推力耦合 牛顿冲击理论

Abstract： For hypersonic vehicles which use scramjets as their propulsion systems, there is a potential coupling effect between engine thrust and structure flexibility, which may result in thrust coupling aeroservoelasticity (ASE). In order to research the mechanism and effect of the coupling, the longitudinal dynamic characteristics of a simple air-breathing hypersonic vehicle with a scramjet are studied. A general methodology to model and analyze the thrust coupling aeroservoelasticity of this kind of hypersonic vehicles is developed, which takes into consideration the coupling of structure flexibility, unsteady aerodynamics, propulsion system and flight control system. The unsteady aerodynamics of the hypersonic flow is computed using Newton impact theory, and the engine performance is analyzed based on one-dimensional flow assumption. Simulation results indicate that, the coupling of the propulsion system affects obviously the short period mode and the aeroservoelastic characteristics of a hypersonic vehecle. The aeroservoelastic stability margin of the numerical example in this paper is decreased by 16%, which should be brought to the attention of those concerned with flight control system design.

Keywords： hypersonic vehicle aeroservoelasticity scramjet thrust coupling Newton impact theory

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