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高超声速飞行器控制一体化设计

Control integrated design for hypersonic vehicle

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英文关键词:control integrated hypersonic vehicle conceptual design modeling control system design

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中文摘要：

针对高超声速飞行器模型具有气动/推进/控制强耦合和强非线性的特点,提出了一套面向控制的一体化设计方案.在概念设计阶段,以飞行器控制性能为优化目标,对气动、推进、结构、控制等参数进行一体化综合优选来设计飞行器.考虑模型生成的保真度要求和计算效率,建立高超声速飞行器参数化的数学模型,并设计LQR(linear quadratic regulator)跟踪控制器.通过不断调整飞行器构型,比较控制相关的动静态特性和控制效果,面向控制需求选择新的飞行器构型,并进行了仿真验证.仿真结果表明:控制一体化设计方法应用于高超声速飞行器概念设计初期可以扩大飞行包线,有效增大失速裕度,减小油耗,提高操纵面效能,降低发动机壅塞制约,对高超声速飞行器的设计效率和控制性能的提高起到了指导性的作用.

英文摘要：

Since hypersonic vehicles involve characteristics of strong coupling of aerodynamics/propulsion/control and nonlinearity, a suit of control-oriented integrated design tool was developed. In the conceptual design phase, considering the aircraft control performance as the optimization goal, the vehicle was designed based on integrated and optimized parameters of aerodynamic, propulsion, structures and control. Considering the fidelity requirement and computational efficiency of the model generation, a parameterized mathematical model was established and an linear quadratic regulator(LQR) reference command tracking control system was designed. The design parameters were adjusted constantly, and then the trade-off study of the control-relevant static and dynamic properties and the comparison of control effects were accomplished. Finally, a new shape of vehicle was chosen according to the control requirement, and the corresponding validation of simulation was accomplished. Simulation results show that the method of control integrated design applied in the early stage of the conceptual design phase, can expand flight envelope, increase the stall margin effectively, reduce fuel consumption, improve the control surface efficiency, and reduce the engine choking restriction. Thus the method of control integrated design plays a guiding role in improving design efficiency and the performance of control for hypersonic vehicles.

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