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MULTIDISCIPLINARY DESIGN OPTIMIZATION OF SSTO AIR-BREATHING COMBINED CYCLE PROPULSION REUSABLE SPACE TRANSPORTATION SYSTEM

Abstract

Multidisciplinary design optimization (MDO) is an important approach for the design of aerospace vehicles, because they are characterized by various disciplines that strictly couple with one another. An MDO problem of a SSTO air-breathing combined cycle propulsion reusable space transportation system is formed and solved in this study. The disciplines integrated in the MDO framework include geometry, aerodynamics, aeroheating, propulsion, and flight dynamics. Special attentions are paid to the accuracy and the computational time in each discipline analysis model. For example, the vehicle external flow is solved using an inviscid CFD technique on adaptive multi-level Cartesian meshes, the engine internal flow is solved using a quasi-one-dimensional method, and the viscous effects (friction and aeroheating) are then calculated using a streamline-traced approach. The trajectory is optimized using a local collocation method on nonuniform grid across time, which features in both accuracy and efficiency. The rigid body characteristics such as the trim and stability are also modeled. Moreover, the interactions between air-breathing propulsion and flight dynamics are studied. Research shows that, the design of the vehicle and its flight trajectory are successfully optimized simultaneously. Furthermore, the characteristics of the optimal solution, especially the relationships among the airframe-engine integration, the rigid body characteristics, the flight trajectory and the payload capability, are investigated.