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考虑禁飞圆的滑翔式机动弹道与气动特性参数耦合设计

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Coupled Design of Maneuver Glide Reentry Trajectory and Aerodynamic Characteristic Parameters Considering No-fly Zone

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摘要

为获得滑翔式再入飞行器最佳气动与弹道机动性能,针对规避禁飞圆的远程滑翔式再入问题提出了一种机动弹道与气动特性参数耦合设计方法。耦合设计外环以气动特性参数为设计变量,基于抛物阻力极线模型提取最大升阻比和对应升力系数为气动特性参数;耦合设计内环以泛化升力系数和侧倾角为设计变量,获得给定升阻特性下能规避禁飞圆且满足再入走廊要求的滑翔式再入轨迹。耦合设计问题以再入驻点总热流最小为优化目标,以再入走廊、终端位置和速度为约束,求解满足弹道机动要求且目标函数最小的最佳气动特性参数。提出了一种规避禁飞圆的侧向几何制导逻辑用于内环轨迹设计。仿真算例得出禁飞圆半径越大,需要的滑翔式再入飞行器最大升阻比越大,且再入轨迹刚好能绕过禁飞圆。仿真结果验证了耦合设计方法和侧向制导逻辑的有效性,该方法可为飞行器方案设计时的气动布局选型等工作提供参考。

关键词： 高超声速 气动特性 耦合设计 禁飞圆 拟平衡滑翔

Abstract:

A coupled maneuver trajectory and aerodynamic characteristic parameters design approach considering no-fly zone is developed to obtain the best aerodynamic and maneuver performance of a glide reentry vehicle. The aerodynamic characteristic parameters achieved by a parabola drag model are taken as the design variables of the outer loop of the coupled design. In the inner loop, the normalized lift coefficient and bank angle are modulated to get a reentry trajectory while avoiding the no-fly zone at a given lift-drag ratio. For the goal of the minimization of the heat load, the best aerodynamic property parameters are designed to achieve the maneuver ability with the constraints of the position and velocity. A lateral geometry guidance is developed to generate the reentry trajectory in the inner loop. The numerical simulation indicates that the larger the radius of the no-fly zone is, the higher the lift-drag ratio is required of the vehicle for the reentry trajectory to just go around the no-fly zone. The results demonstrate that the coupled design approach is effective and can provide a useful reference for aerodynamic configuration design.

Keywords: hypersonic aerodynamic characteristic coupled design no-fly zone quasi-equilibrium glide

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