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MISSION OPTIMIZATION OF HIGH-SPEED ENTRY FLIGHT TEST FOR DEEP SPACE EXPLORATION VEHICLES

Abstract

When performing earth reentry, deep space exploration vehicles suffer high heat load due to its high entry speed. In order to validate heat protection system performance thoroughly, entry flight tests are often carried out for deep space exploration vehicles, especially for crew vehicles.

Generally, deep space exploration vehicles entry in or over second cosmic velocity and thus suffer high heat load. For the sake of retrenching funds and reducing mission risk, deep space exploration vehicle flight tests often perform earth entry in large flight path angle and relatively high speed, instead of entry in second cosmic velocity. This strategy have been verified by several crew deep space exploration vehicles, such as entry flight test 1 for "Orion" multi-purpose crew vehicle and AS 201 flight test for "Apollo" crew vehicle.

In this study, we propose an optimization method for initial entry condition of high-speed entry flight test. Initial entry condition, including fight path angle and entry velocity, is critical for flight test success. By designing proper initial entry condition, we can achieve the same heat rate or the same total heat load to that of second cosmic velocity entry flight. Firstly, we establish orbital dynamics and entry dynamics for flight trajectory design, and set heat load computation method to evaluate heat load during entry flight mission. Secondly, we conduct experimental design to select several typical parameter combinations of initial entry condition, and then evaluate the corresponding heat load on these selected combinations to establish a surrogate model for the evaluation. Finally, on restrictions of entry downrange, aerodynamical load and heat load, we perform different optimization algorithms to stepwise achieve an optimal initial entry condition based on the aforementioned typical parameter combinations. We validate the proposed method by an entry flight test mission, and simulation show that the exact heat load is acquired with reducing 2.1 km/s velocity demand at least.