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Author: Mr. zichen zhang
Northwestern Polytechnical University, China

Dr. Chunlin Gong
Northwestern Polytechnical UniversityNPU, China
Dr. jianlei wang
Northwestern Polytechnical University, China

JOINT OPTIMIZATION OF STRUCTURE AND PROPULSION SYSTEM FOR LAUNCH VEHICLES

Abstract

Space launch vehicles serve as the primary means for human access to space, with over 200 rockets delivering over a thousand tons of payload into Earth orbit and universe space in 2023 alone. Improving the efficiency of rocket payload delivery under existing technological constraints promises significant economic benefits.

During the launch process, the maximum dynamic pressure point represents the peak aerodynamic load throughout the flight, while just before the separation of the first stage marks the peak acceleration. These two stages denote the most demanding structural load conditions for the entire rocket. Currently, to alleviate these structural loads, engine thrust is typically reduced approaching these points. However, reducing engine thrust diminishes engine efficiency, thereby affecting the overall payload efficiency of the rocket. Conversely, maintaining high thrust without reducing it necessitates increasing structural mass to withstand the more severe loading conditions, which also lowers the overall payload efficiency of the rocket. Simply opting to decrease engine thrust or increase structural mass individually is not the optimal solution.

This article proposes a method to optimize payload efficiency by striking a balance between reducing thrust and increasing structural mass. Through numerical simulations, the proposed optimization approach is validated, demonstrating improved payload efficiency results compared to conventional methods. By carefully managing the trade-off between engine thrust and structural weight, the proposed method aims to maximize the efficiency of rocket payload delivery, thereby enhancing the cost-effectiveness of space launch operations.