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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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UNCERTAINTY-BASED MULTIDISCIPLINARY DESIGN OPTIMIZATION FOR LAUNCH VEHICLE

Abstract

The launch vehicle is a complex engineering system with multiple disciplines (subsystems), among which there are complex couplings. In order to get the optimal design of the launch vehicle on the basis of fully considering the coupling relationship of each subject, we need to use the multidisciplinary design optimization method (MDO). MDO based on uncertainty theory is an important branch of MDO, this method not only considers the coupling relationship of each subsystem, but also considers the influence of uncertain factors on the system, which can improve the reliability and robustness of the design scheme. Based on the analysis and simplification of the whole process of launch vehicle design, this paper puts forward the overall design method of carrier rocket with three disciplines, such as structure, aerodynamic and trajectory, and establishes the whole system analysis model of the carrier rocket based on the analysis model of each subject. And further established a MDO model with the minimum takeoff mass as a goal. Then, consider the uncertain factors, probability-based gradient method (PGM), probability-based Monte Carlo method (PMM), and interval-based gradient method (IGM) are used to analyze the uncertain transmission of the system response and to establish the uncertainty-based MDO model of the launch vehicle. Using the resampled particle swarm optimization algorithm (PSO) to solve the deterministic MDO model and the three above-mentioned uncertainty-based MDO models of the launch vehicle. Compared with the deterministic MDO model, the takeoff mass of uncertainty-based MDO model is slightly increased, but the standard deviation is reduced. It is shown that the optimization model based on uncertainty has stronger anti-interference ability and higher probability of satisfying the constraint condition, that is to say, it is more reliable and robust. It also proves that the uncertainty-based multidisciplinary design optimization for launch vehicle is feasible and effective.