SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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MULTI-OBJECTIVE OPTIMIZATION OF HYBRID ROCKET MOTOR AND DECISION-MAKING USING A HYPER-RADIAL VISUALIZATION METHOD

Abstract

Hybrid rocket system design problem is one typical multidisciplinary design optimization problem. A simultaneous design optimal method was used, based on multi-island genetic algorithm, for the design of the hybrid rocket motor and the rocket trajectory in this paper. And a mathematic model of the hybrid rocket system was established in which the minimization of the rocket initial mass and axial overload and the maximization of the specific impulse and rocket trajectory vertex distance were considered as four objective functions. Considering the complexity of high-dimension multi-objective design optimization problem and the difficulty to acquire the global optimal design with single objective optimization algorithm, the Non-Dominated Sorting Genetic Algorithm (NSGA) in the iSIGHT multidisciplinary design optimization software was applied to generate the Hyperspace Pareto Frontier (HPF). Since the high-dimensional HPF cannot be represented in Cartesian coordinates directly and cannot be handled well by the traditional visualization methodology, the Hyper-Radial Visualization (HRV) method was applied in this paper. This method can visualize the HPF in 2D performance space intuitively and can enable designers to quickly identify better regions and to choose the best solution. Besides, for the purpose of choosing a more specific design solution, the designers' preference was incorporated by the weights and color marks with equal and variable range-based preferences in the HRV. Finally, an optimal design of rocket initial mass was accomplished by means of the weights and a global optimal design of hybrid rocket motor was accomplished via incorporating the color marks principle. The results indicated that the simultaneous design optimization of the hybrid rocket motor and the trajectory and the application of multi-objective optimization algorithm can contribute to generate the global optimization of the hybrid rocket design, and the HRV method can help to choose the most desirable solution (or solutions) from amongst the HPF, and the incorporation of weights can assist to seek out the specific design solution, and the color marks with equal and variable range-based preferences can help to determine the global optimization efficiently.