SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (1) (1)

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MULTIDISCIPLINARY DESIGN OPTIMIZATION OF A SPACECRAFT BI-PROPELLANT PROPULSION SYSTEM USING A COMPUTATIONALLY IMPROVED FRAMEWORK

Abstract

Space propulsion systems play an increasingly important role in planning of space missions. Bi-propellant thrusters, due to their relatively simple design, low development costs and high reliability, have been widely used in the field of space propulsion. The conceptual design phase of a bi-propellant thruster contains interaction between specialized disciplines such as thrust chamber, propellant tanks, structure analysis and pressurization system, to mention a few, often with conflicting objectives and constraints. In general, design of a bi-propellant thruster is a complex and multidisciplinary process. For example, the designer of these systems is faced with many design issues including how oxidizer and fuel are synthesized, how the thrust chamber should be cooled, how many injectors should be used, and how to evaluate different thruster configurations. Recently, emphasis has been on the advances that can be achieved with the interaction between two or more disciplines. It is fundamentally a multidisciplinary and multi-objective process. The principled application of formal optimization techniques to complex system design has led to the rapid development of an optimization field named Multidisciplinary Design Optimization (MDO). The aims of this study are to implement and compare Multidisciplinary Feasible and Collaborative Optimization architectures for the multi-Objective optimization of a bi-propellant space propulsion system design. Several disciplines such as thrust chamber, cooling, and structure were exploited in a proper combination. The main optimization objectives in the MDO frameworks were to minimize the total wet mass and maximize the total impulse by considering several constraints. Surrogate-modeling as an efficient tool was used to decrease computational cost in discipline (subsystem) level, within MDO frameworks. In the field of bi-propellant space propulsion systems, the coupling of objective functions due to the design variables (such as chamber pressure, oxidizer to fuel ratio, propellant type, etc.) in an engineering design process will results in difficulties for evaluating and comparing various thruster options. In the present paper, by solving the design problem in the MDO frameworks, a set of Pareto solutions was obtained. The presented design methodology provides an interesting decision making approach to select the best system parameters of space propulsion systems under conflicting goals.