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MULTIOBJECTIVE SHAPE OPTIMIZATION OF ENTRY AEROSHELLS USING GENETIC ALGORITHM

Abstract

In this work a capability has been developed that utilizes multiobjective optimization to identify hypersonic entry aeroshell shapes that will increase landed mass capability. Aeroshells are designed to protect payloads from high aerodynamic heating and loads encountered during the descent phase of flight. The Aeroshell is designed to provide these functions with minimum possible mass so that useful landed mass can be maximized. Other geometric considerations included in the design are the maximum drag, the volumetric efficiency (affecting payload packaging) and the aero-heating. These objectives cannot be simultaneously optimized to their fullest extent – some level of trade-off will be required. The conflicting of several objectives suggests the Multi-Objective optimization methods be employed that allow the consideration of several objectives simultaneously while satisfying all necessary constraints. Therefore, given a set of mission requirements that define constraints, the aeroshell shape can be optimized in a Multi-Objective sense. Genetic Algorithms (GAs) which are originally inspired by biological evolution and natural selection provide an alternative for solving optimization problems. Moreover, Multi-Objective Genetic Algorithms (MOGAs) consistently outperform other traditional optimization methods in most of the Multi-Objective problems. In this study a MOGA is used to produce a set of feasible solutions called Pareto-optimal solutions for the aeroshell design problem. After deriving design constraints based on a common mission, the MOGA was performed using drag-area, volumetric efficiency, and aero-heating (say and Riddell stagnation point relation). Aeroshell shapes are parameterized using splines to generate complete aeroshell surfaces. Hypersonic aerodynamic objectives and constraints are computed by numerically integrating pressure coefficient distributions obtained using Hypersonic Newtonian flow theory. In this work aero-heating is considered including two layers of coating and structure. One of the main characteristics of this work is the consideration of thermal protection system mass on aeroshell shape design. In this respect, Stagnation-point heating is estimated using an effective nose radius .Results revealed solutions that offer improvement in these objectives. These sets of Pareto-optimal solutions also served to highlight the fundamental trade-offs between drag-area and volumetric efficiency as well as aero-heating.