Paper ID: 60768
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Vehicles – Mechanical/Robotic/Thermal/Fluidic Systems (7)

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RELIABILITY-BASED MULTI-OBJECTIVE DESIGN OPTIMIZATION OF THE SATELLITE THERMAL CONTROL SYSTEM USING SWARM-BASED OPTIMIZATION ALGORITHMS

Abstract

Thermal Control System, as a vital element of a satellite, has the responsibility of maintaining the temperature of other subsystems in a permissible range. Designing a thermal control system for a satellite is a challenging task with different design variables and also multiple objectives. There are different studies in the literature aiming the design of a thermal control system employing multi-objective optimization methods. In these researches most of the attention is paid to the thermal system simulation and the least consideration is conducted about the proper implementation of the optimization algorithm and it's parameter settings according to the problem which is showed in this study that has a notable effect on the final design solution in comparison to the similar thermal control system design problems. Also considering uncertainty in the design of thermal system in another challenging task that is addressed in this paper. Therefore, the thermal system simulation software development and the validation will be discussed first. The software simulates the position of the satellite in any desired orbit and calculates thermal flux of direct solar, albedo, and planetary radiation heat flux to the satellite and internal thermal dissipation and emittance to deep space. A combination of three commonly used thermal control methods in small satellites including a radiator, multilayer insulation, and a heater are used. The cost, mass and power consumption of the thermal control system are chosen as the objectives of the multi-objective optimization problem. Insulation thickness, radiator cover thickness, and the power of the heater are considered as design variables and the minimum and maximum value of allowable surface temperatures are considered as design constraints. In order to reduce the likelihood of the violation of the constraints, after modeling the uncertainties, reliability-based optimization is used. For this purpose, the Monte Carlo method is applied to estimate the reliability of constraints. For the optimization process 3 types of the most promising optimization algorithms including Accelerated PSO, CMA-ES, Multimodal FGA have been applied and the result compared with GA which has been utilized more than other methods for the optimal design of the thermal control system. The results show that the design is considerably improved by using swarm-based optimization algorithm rather than classic GA for both deterministic and design under uncertainty.