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ANALYSIS OF EFFECTIVE THERMAL CONTROL DESIGNS FOR SMALL SATELLITES

Abstract

Small satellites are gaining popularity in the space industry owing to their reduced cost, mass-production ability and quicker development time. Satellites go through large temperature swings during their mission lifetime under the effects of the space environment such as varying solar flux, albedo and planetary IR when in orbit. Experiments carried in them and the electronic devices used are vulnerable to the extremes of temperature and radiation. Maintaining the satellite within its optimum operational range of temperature, given the mass and power constraints of a small satellite, is a challenging task. The purpose of this study is to analyze and provide an organized and complete resource to aid in the design and analysis of small satellite thermal control systems.

The thermal design process starts with identifying the system's requirements, then iteratively analyzing, designing, and reanalyzing the system. All satellite components must have their temperature requirements determined, as well as the satellite heating environment. Different combinations of passive components like MLIs, surface coatings, radiators, heat pipes, phase change materials and active components like heaters, thermoelectric coolers, and louvers, are analyzed based on different mission requirements. The efficiency of technological advancements such as flexible PGS heat spreaders, metamaterials for surface coating and passive heat switches are investigated for small spacecraft.

Using numerical methods such as Finite difference approximation, Finite element approximation and softwares such as SINDA, ANSYS and Thermal desktop, the effectiveness of each component and the thermal model of a satellite is investigated. Both steady and transient cases are considered and the extreme case temperatures are determined. In this study, the various types of heat loads that a satellite would experience over the course of its lifetime, as well as a practical description of the thermal model components, analysis and design process are investigated and evaluated using modern computer software.