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

Author: Dr. Kikuko Miyata
Meijo University, Japan, kmiyata@meijo-u.ac.jp

Dr. Masaki Yamagata
Kansai University, Japan, yamagata@kansai-u.ac.jp

TEMPERATURE STABILIZATION DEVICE'S DESIGN AND IMPLEMENTATION METHOD FOR NANOSATELLITE SYSTEM

Abstract

There are a lot of difficulties in the design of the nano-satellites' thermal design and operations, such as the periodic heating and cooling caused by orbital motion or vacuum. In addition, nano-satellite has strict mass and volume limitations that cause small power generation and consumption and low heat capacity, which cause lower temperature conditions compared with the larger spacecraft and higher temperature variations and make the thermal design difficult. These difficulties cause requirements for a temperature change mitigation system with low power consumption. Therefore, this paper proposes the utilization of commercial phase change materials (PCMs) and effective system design methods with PCMs. The system mitigates temperature change by incrementing the heat capacity around the designed temperature, which realizes power resource usage reduction for temperature mitigation. The proposal consists of a selection of PCMs, a discussion of suitable implementation methods, and a discussion of a system design method for small spacecraft using PCMs. The popular PCMs tend to use solid/liquid phase transformation, and we have to consider the design of a closed container and volume changes. In addition, the PCMs tend to have small thermal conductivity, which prevents effective temperature mitigation of the target device. Here, we perform the trade-off of some kinds of PCMs and application methods. The discussions on the selection and implementation of PCM are performed via experimental validations. The discussion concludes with the utilization of a VO2-based solid-solid PCM block formed with epoxy resins, and suitable thermal path implementation. The discussions on a system design method are performed through numerical validations including system modeling with experimental validation. Here, we chose a 1U CubeSat system as an example. We perform thermal design focusing on the electric power system, especially the battery module. The results show the effectiveness of the proposed method and system.