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Author: Prof. Taig Young Kim
Korea Polytechnic University, Korea, Republic of, tagikim@kpu.ac.kr

ANALYTIC DESIGN OF THE PHASE CHANGE MATERIAL FOR THERMAL CONTROL OF THE SATELLITE COMPONENT IN PERIODIC DUTY

Abstract

The analytic method to design the thermal control hardware using solid-liquid phase change material(PCM) for periodically working satellite electronic components is investigated. In the simplified energy equation of the system composed of component and PCM thermal control modules, the radiation heat-discharge term, which is a biquadratic equation of temperatures, is linearized, and approximate analytical solutions that guarantee minimum errors under physically valid conditions are obtained. An equation between the dimensionless thermal capacity of PCM and radiator area is derived for arbitrary design input data from the approximate solution. Stable periodicity of temperatures is insured when thermal balance is maintained between the net thermal energy accumulated in the system during heating period and the net thermal energy discharge to space during cooling-off period. From the thermal balance, restrictive conditions for the thermal capacity of the PCM and the area of radiators are drawn. If the thermal capacity of the PCM increases, resulting difference in temperature profiles during heating phase will be very small. However, cooling rate during the component off-duty phase will be slow down, and this will reduce the duty cycle of the compensation heater. Finally, the analytic equation for mass optimization is presented to minimize the system mass.