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EXPERIMENTAL STUDY OF HEAT SWITCH RADIATOR USING SHAPE MEMORY ALLOY FOR HIGH INSULATION SYSTEM

Abstract

The surface temperature of a spacecraft is determined by heat input and thermo-optical properties of the surface material, such as solar absorptance and infrared emissivity. As the solar incident accounts for the largest percentage of heat input, the temperature tends to be high in the sunshine and low in the shade. In general, the area of the radiator with low solar absorptance and high emissivity is optimized for the hot case, thereby, it tends to be too cold in the shade. To slow down this temperature drop without heater power, a radiator whose infrared emissivity can be changed depending on the temperature (large emissivity at high temperatures and low emissivity at low temperatures) is required. Moreover, when the spacecraft is exposed to low temperature environment for a long duration, high insulation system with minimal heater power consumption is required. These requirements can be realized by covering almost all the spacecraft with polyimide foam multi-layer insulator (PF-MLI) with minimal cutout parts of it, and by using mechanically pumped fluid loop in order to integrate waste heat to one radiator. In addition, the radiator is required to control the internal temperature of the spacecraft within a proper range. The radiator which we have been developing has heat switch actuator mechanism using a shape-memory-alloy spring. It can change effective emissivity by changing thermal conductance between the radiator and a heat source. In addition, it is expected to change effective emissivity rapidly within a narrow temperature range, so that the radiator can reduce heater power and prevent the working fluid from freezing. We report the results of several performance tests. Firstly, we measured the thermal conductance in a vacuum chamber and confirmed its temperature dependency. A rapid change of thermal conductance around the temperature of martensitic transformation was observed. In addition, effective emissivity was calculated by using the measured thermal conductance with Thermal Desktop. Secondly, we measured its effective emissivity from 0 deg-C to 40 deg-C by calorimetry method. Finally, we compared the measurement results of effective emissivity to thermal analysis, and confirmed the validity of experimental results. From these measurement results, we evaluated the performance of the Heat Switch Radiator in comparison with a thermal louver, which is the traditional variable emissivity radiation device. We also analyzed the case of a periodically changing thermal environment, and confirmed heater power reduction.