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EVALUATION OF EFFECTIVE EMISSIVITY OF NEW THERMAL INSULATION USING POLYIMIDE FOAM FOR SPACECRAFT

Abstract

Conventionally, multilayer insulation (MLI) has been used for spacecraft, and known for high performance thermal insulation. MLI blanket is composed of multiple layers of low emittance films with spacers. The layers are stacked and sewn together at the edge, and attached to the spacecraft using Velcro on one side of MLI blanket. Though, heat losses through Seam and Velcro make the performance of MLI degraded. Saving heater power is the key factor for deep space missions or lunar exploratory missions. Therefore, local thermal insulation performance degradation is unacceptable. In order to respond to this situation, we focus on polyimide foam (PF) and propose polyimide foam multilayer insulation (PF-MLI), which might show superior performance compared with conventional MLI blanket. Thermal conductivity of PF measured and estimated in this study change with density, and local minimum value, are ascertained from both measurement and estimation. Based on these results, the optimum configuration (layers, density, etc.) of PF-MLI is determined. PF-MLI is composed of aluminized films and PF between films. Two different types of PF are used for PF-MLI and compared with Standard MLI Blanket in terms of effective emissivity and weight. Type BF301 (6 8 kg/m3) with aluminized films and Type BP101 (29 33kg/m3) with aluminized films are the measurement samples as PF-MLI, and two different layer numbers are fabricated in each sample. Guarded hot plate method, which is useful heat flux measurement method with reducing heat loss, is applied to measure effective emissivity in a vacuum steady state condition. Effective emissivity is calculated from the higher temperature, colder temperature of the sample, and heat flux thorough the sample from Stephan Boltzmann law in a steady state. As a result, effective emissivity of PF-MLI is lower than that of Standard MLI in higher temperature range from 260K to 340K, and it can be concluded that especially PF-MLI using BF301 (7.2 kg/m3) is the optimum thermal insulation from the standpoint of lighter weight and higher performance. Seam effect on degrading the performance is also tested by experiment, and heat loss is critical to degrading the performance in Standard MLI, but not in PF-MLI.