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PERFORMANCE ENHANCEMENT OF COOLER MICRO-VIBRATION ISOLATION SYSTEM BY IMPLEMENTING THERMAL DESIGN WITH GRAPHITE SHEET

Abstract

The pulse tube type cryogenic cooler is widely used in the space field to cool down the focal plane of an imaging sensor to low cryogenic temperature. However, the pulse tube type cooler generates undesirable micro-vibration. To obtain a high-resolution image, micro-vibration isolation is an important task. The micro-vibration of the cryogenic cooler can be isolated by using such a passive vibration isolator with low stiffness spring that decouples the main driving frequency of the cooler and the natural frequency of cooler assembly supported by the vibration isolator. Furthermore, the thermal design to ensure the operating temperature of the cooler is one of the main factors to guarantee cooling performance and reliability. In general, the heat pipe is implemented on the cooler to transfer heat from the cooler to the radiator. However, if the stiffness of the heat pipe is increasing, it may lead to a decrease in the vibration isolation performance of the passive vibration isolator, which is supported with low stiffness springs. To satisfy the vibration isolation performance in on-orbit, the bend-shaped heat pipe is applied to keep the low stiffness of the heat pipe. However, it may be difficult to apply the bent-shape heat pipe in the small satellite, because of stricter volume requirements compared to a large-scale satellite. In this study, we proposed a new thermal design of the cryogenic cooler by using a graphite sheet with flexibility, high thermal conductivity, and low stiffness. This new thermal design strategy to use flexible graphite sheets is more beneficial in terms of vibration isolation performance than conventional bent-shape heat pipe because this enables to support the cooler with a much lower stiffness of isolation system. In addition, the flexible characteristic of the graphite sheet contributes to alleviating the mechanical design constraints such as the location of the heat pipe mounting interface on the radiator. Furthermore, this is unnecessary to maintain the horizontal orientation of the heat pipe to avoid the gravitational effect during on-ground test. The feasibility of the newly proposed thermal design strategy was validated through a free vibration test and micro-vibration isolation performance test using a dummy cooler.