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Study for Continuity of Cooling Operation of SPICA Cryogenic System by Adding Refrigerant Circulation System

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SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is a pre-project mission of JAXA to launch a large infrared observatory to the second Sun-Earth Lagrangian liberation point (L2) in the 2020s. A unique feature of SPICA cryogenic system is a warm launch system using radiative cooling and a large number of mechanical coolers in orbit to cool 2.5m-class large IR telescope below 8K and its detectors in sub kelvin. The latest concept of SPICA uses a sub-Kelvin cooler consists of an adiabatic demagnetization refrigerator (ADR) and a sorption cooler, two sets of 1K-class Joule-Thomson coolers (1K-JT cooler) and two sets of 4K-class Joule-Thomson coolers (4K-JT cooler) with three sets of two-stage Stirling (2ST) coolers used as pre-coolers respectively for redundancy and reliability. Additionally, two 2ST coolers are used to cool the telescope shields. The pre-coolers for 1K-JT cooler should be separated from 4K-JT cooler because of the influence of the pre-cooler's failure as well as a required pre-cooling temperature for 1K-JT cooler lower than that for 4K-JT cooler. This paper proposes an improvement for continuity of cooling operation of SPICA cryogenic system by adding refrigerant circulation system. The added refrigerant circulation system are increased the redundancy and reliability of SPICA cryogenic system that if a pre-cooler or a JT compressor is stopped. As additional effects, number of the pre-coolers are decreased to two from three and the arrangement limitation of thermal link and heat exchanger assemblies are also degreased. This paper describes theoretical analysis based on enthalpy to understand design method for the refrigerant circulation system. Results of the heat balance analysis using several parameters are demonstrated.