ME PhD Thesis Defense

Development of PCM Coupled Heat Pipe for Space Application

Mr. Venkata Raghavendra (ERP)
Scientist at the UR Rao Satellite Centre of ISRO, Bangalore, PhD Student, Mechanical Engineering, IISc

ABSTRACT

A key challenge in the design and reliable operation of a spacecraft is to provide an effective thermal control system that accommodates large heat dissipation from electronic packages and varying orbital heat loads from Sun, Earth and other planetary bodies. Thermal control system of a satellite is designed to maintain the temperature of all subsystems within their specified limits by means of heat storage, heat transfer to the outer surface through conduction and heat rejection to deep space through radiation. This research work provides an insight on the coupling of a heat storage unit and a heat transfer device for spacecraft thermal control. The use of solid - liquid phase change materials (PCM) to store the waste heat during transient operations are gaining prominence in the spacecraft applications. Axially grooved aluminium-ammonia heat pipes are extensively used to efficiently transfer waste heat from electronic packages to thermal radiator of the satellite. 'PCM coupled heat pipe' is an innovative system which stores large amount of heat for a shorter duration in an orbit and releases this heat gradually for a longer duration, thereby reducing the thermal control mass, volume and heater power requirement in a spacecraft. The design, development and qualification of 'PCM coupled heat pipe' for use in spacecraft thermal control application are presented here.

The transient operation of the heat pipe is investigated and key parameters such as equivalent thermal conductivity and heat capacity of the heat pipe are theoretically estimated and experimentally evaluated. A thermal Resistance - Capacitance (RC) network model is developed to design a PCM module for operation in space environment. Two PCM modules are designed and realized, out of which one is subjected to stringent space qualification tests and the other one is flown as flight experiment onboard GSAT-29 spacecraft. The flight experiments are successfully carried out under microgravity environment in orbit, and it is demonstrated that the PCM coupled heat pipe performance did not degrade even after one year of operation in the orbit.

ABOUT THE SPEAKER

Venkata Raghavendra, Scientist at the UR Rao Satellite Centre of ISRO, Bangalore, is a PhD scholar in the Department of Mechanical Engineering, IISc, under the ERP programme. For his PhD, he has been working with Prof. Pradip Dutta, Prof. Pramod Kumar and Dr. Alok Kumar Shrivastava (ISRO) in the field of PCM coupled heat pipe for space application. He graduated in Mechanical Engineering from University Visveswaraya College of Engineering, Bengaluru. He did his post-graduation in Heat Power Engineering from the National Institute of Technology Karnataka (NITK), Surathkal, India. His research focuses on heat transfer and thermal control of spacecrafts.

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