CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S0327

Project Title

Innovative Thermal Regulation Device for Small Satellites Using a Phase-Changing Substance

Abstract

Objectives/Goals

A CubeSat is a small satellite, where 1U, measures 10cm^3. These satellites can be built in different sizes, such as 1U, 2U, etc. They serve a variety of functions including technology demos and Earth imaging. The first CubeSat missions had short lifespans. More recently, these satellites have been proposed for complex endeavors such as interplanetary missions. A combination of on-board electronics, the sun#s radiation, the Earth#s own infrared radiation and albedo radiation causes these small satellites to overheat and damage important components and avionics and can lead to a total loss of the satellite. It is therefore necessary to ensure that satellites will function for extended periods.

Methods/Materials

The device proposed in this project is designed for use in micro-class satellites and can be scaled for larger satellites. A rectangular vessel with hollowed halves was created using a CAD software. Each half was filled with melted paraffin, then screwed to seal the container after the paraffin cooled. Filling with liquid paraffin maximized the mass inside the vessel and also prevented possible leakage due to change in volume expansion during phase change. Paraffin has a melting point lower than the critical temperature of most on-board electronics, and can be used without damaging the aluminum casing. Measurements using a controlled heat source were used to confirm heating properties. Three methods were used to corroborate temperature data.

Results

Paraffin provides sufficient phase-changing performance at low powers. The first test was consistent with a heat curve that demonstrated the heat of fusion of paraffin. Further energy input after this point caused the temperature of the device to increase. This is explained by the energy required to break the bonds for the phase change from solid to liquid (consistent with calculations for the heat of fusion). Data supported this expectation.

Conclusions/Discussion

The device was found to be suitable for applications below 10 W. It can dissipate excess heat into the paraffin's bonds during melting. This energy is released by the paraffin and the casing temperature, decreases. This can keep sensitive electronics from overcooling. Next efforts focus on increasing the paraffin-to-casing ratio in order to increase the energy storage capabilities of the device. Future experiments should be performed in vacuum to test the device in realistic conditions.

Summary Statement

The project studies the characterization of a device designed to store and dissipate heat away from sensitive electronics in small satellites.

Help Received

Equipment used were purchased with support from the Oak Grove High School Science Department and from suggestions from Jennifer Claudio, Science Research instructor. Feedback was received from judges at the NCCAVS Symposium and previous qualifying fairs (SCVSEFA).