PAssive Thermal Coating Observatory Operating in Low earth orbit (PATCOOL)

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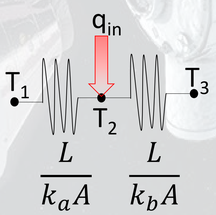
Deep Space Exploration

Long term presence on the moon, mars, and beyond necessitates the transport of liquid oxygen (LOX). Resources are limited in space and LOX not only servers as an oxidizer for fuel, but can also be utilized in the production of breathable air for space habitats. Currently the state-of-the-art thermal control coatings are incapable of maintaining a LOX tank at cryogenic temperatures for the extended periods of time that are inherent to deep space exploration. A new thermal coating being developed at Kennedy Space Center (KSC) has the potential to change all that.

Thermal Circuit Analysis

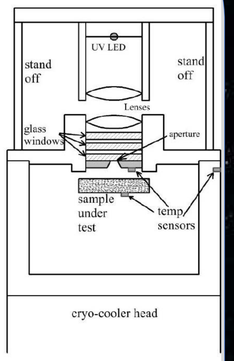
- Thermal circuit analogous to electrical circuit
  - ➢ $I = \frac{V}{R}$ translates to $Q = \frac{dT}{R_t}$
- Thermal capacitance (mC_p)
- Time constant ($\tau = R_t mC_p$)
- Contact Resistance
- Thermal properties (k, ρ, C_p)

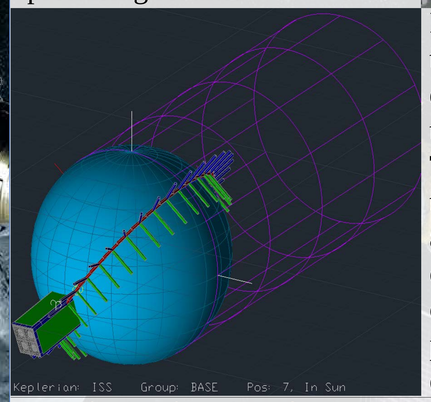


Radiation
- View factor
- Optical properties (α, ε)

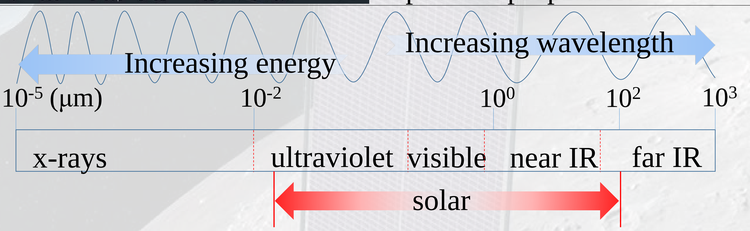
Thermal Desktop

A passive thermal control coating was designed from pressed powder, consisting of scattering particles, and a silver backing. In order to simulate a deep space environment a vacuum chamber combined with a cryocooler was used to test samples of yttrium oxide (Y_2O_3) which are showing promising results.





In addition to laboratory results there is a need for a relatively quick and cheap affirmation of the expected temperature ranges. Thermal Desktop is a simulation tool that enables thermal circuit analysis on a spacecraft and its components. The model is capable of incorporating orbit parameters and wavelength-dependent properties.

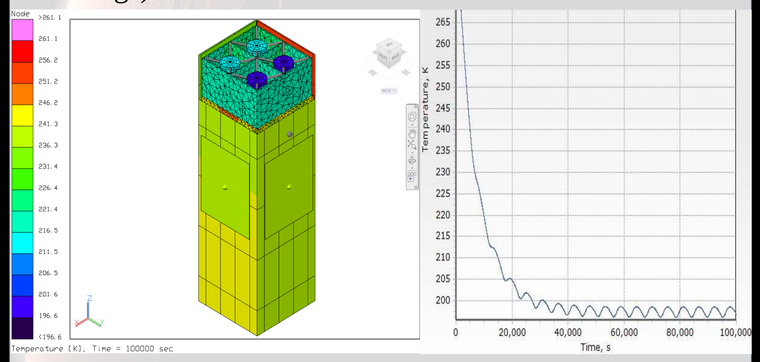


Low Earth Orbit (LEO) Thermal Environment
- ➢ Solar radiation
- ➢ Infrared (IR) planetshine
- ➢ Albedo radiation

Simulation

Four thermal coating samples are going to be flying up in a 3U CubeSat that would potentially mimic the LEO of the International Space Station (ISS). In order to have a direct comparison to the state-of-the-art, two Y_2O_3 samples will be surface coated in AZ93 white paint. The goal of the simulation is to answer the following questions:
- ➢ What is the ΔT between the different coatings?
- ➢ How well are the samples thermally isolated?
- ➢ What are the worst case scenarios?

Preliminary Results
- ΔT = 26K between AZ93 and Y_2O_3
- Y_2O_3 sample fluctuates around 197K (no Kevlar strings)



Significance

A thermal control coating designed to reflect nearly all of the sun's irradiance, while still allowing far-IR emission. Thus harnessing the potential of achieving passive cryogenic cooling in deep space.

Applications
- Cryogenic liquids
- Superconductors