

[Double Strokes Active Heat Pipe for Thermal Control]

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- **Introduction**

In the prospective of space exploration. There is a desire for a multi mission thermal platform. Thermal control systems can be active or passive. The idea of a flying camera compatible with different regimes in space can be applied through a variable thermal control subsystem. Active and passive techniques are used to pass the worst cases hot and cold through the mission. The main question answered in this presentation is to define the capability of heat pipes to work at different failure regimes. This can be managed by the duplication of its conventional usage for cooling to be capable of both heating and cooling.



- **Double Strokes Heat Pipes**

- Double strokes heat pipe is an innovative thermal control technique that can manage both extreme hot and cold failure cases. On sending a small object to deep space two failure regimes must be considered. Double strokes heat pipes are heat pipes with active stroke added for heating. low heating points fluids are suggested for power saving.
- The first stroke is a conventional heat pipe that rejects heat at extremely hot conditions. The second stroke uses another type of fluid (low heating power) which can be used to raise the temperature for extreme cold conditions.



- **Finite Element Analysis**

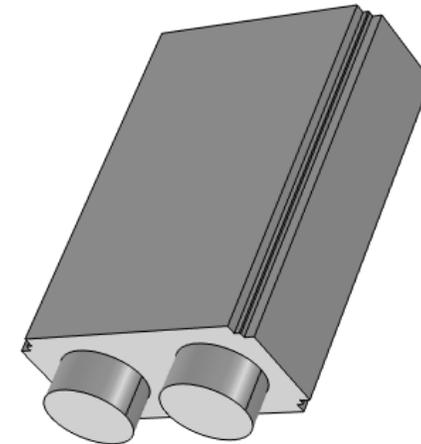
Finite element analysis is done to compute the max. an min. temperatures inorbit thus the failure case regimes can be defined and thermally treated by active an passive techniques. The camera platform suggested following ISIS 6U platform as shown in figure. The selected orbit is 550 km altitude and 97.5 degrees inclination.

- Sources of Heat loads:

Sun: Input solar flux W/m^2

Albedo: 30% of direct solar flux energy

The Earth Infrared: $236 W/m^2$

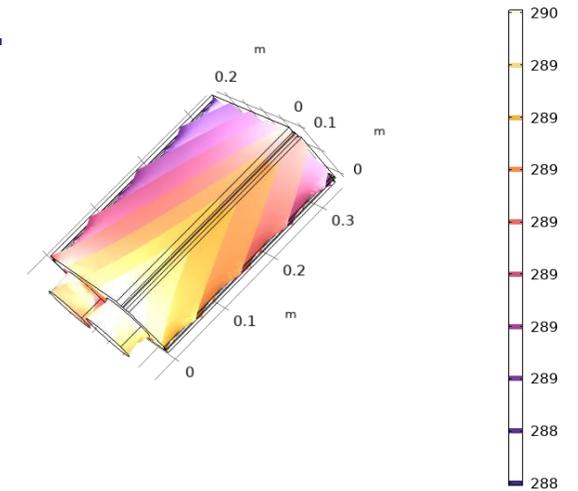
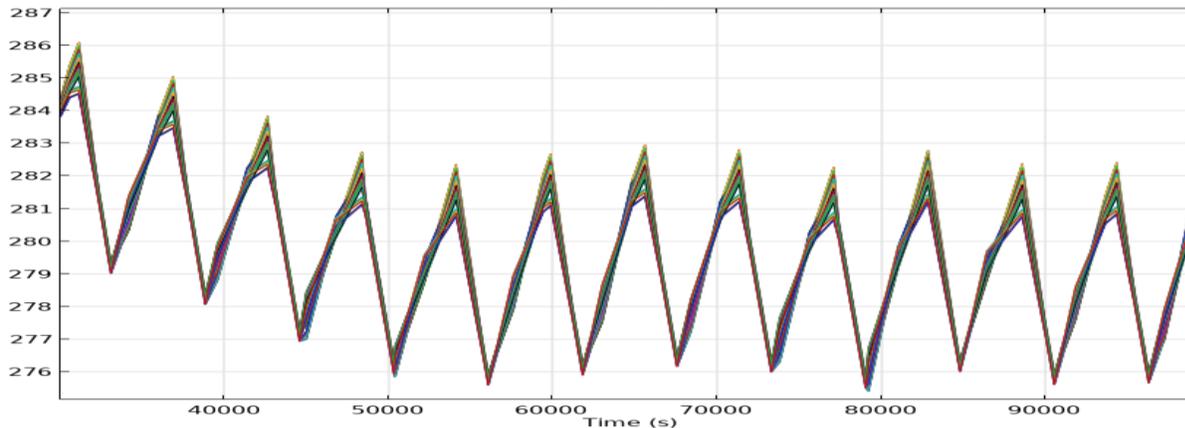
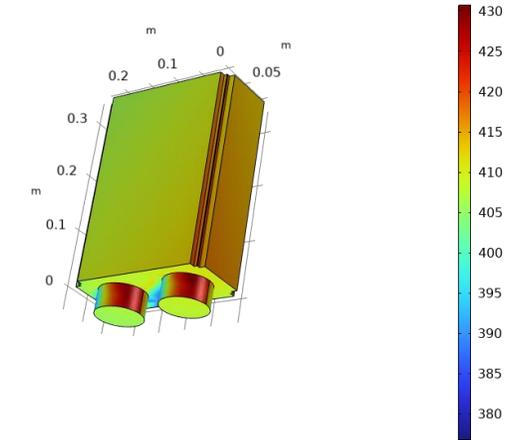




- **Finite Element Analysis**

Surface radiosity reach 430 W/m^2 and total irradiation per orbit are given in Figure.

Temperature fluctuations from illumination to eclipse can be kept by simple optical properties modifications by black anodization to become between 4 degC to about 10 degC which is a workable range for camera operation.





- **Thermal Control Problem**

Till this point of analysis one can ask an important question,

Where is the problem ?

Why innovation is needed to solve thermal problem?

- The main problem is the high temperature transitions arise for a small camera travels into deep space. The platform will not exceed the size of a cubesat. Thermal simulations show a wide temperature range from illumination to eclipse if we use composite materials to design this platform. For the small camera to be workable in all flight regimes we can use the proposed idea knowing that space camera requires a fine temperature gradients to be workable.



- For interplanetary missions, it must be considered that this small camera (space eye) will pass through different situations of heating and cooling across different planets. So, it will pass through earth which receives about 1370 Watts per square meter average solar irradiance, also it will pass through Venus which approximately double the mentioned solar irradiance for earth and mercury which receives average 6.5 to 7 times earths solar radiation.
- On the other side, space eye will pass through Mars which receives less than half the solar intensity received by earth, and the radiation intensity decreases till Neptune which receives about 0.0011 radiation intensity of earth (about 1.5 Watts per square meter). In the mentioned low radiation orbits space eye will face an extreme cold conditions either it is orbiting in illumination or eclipse zones.

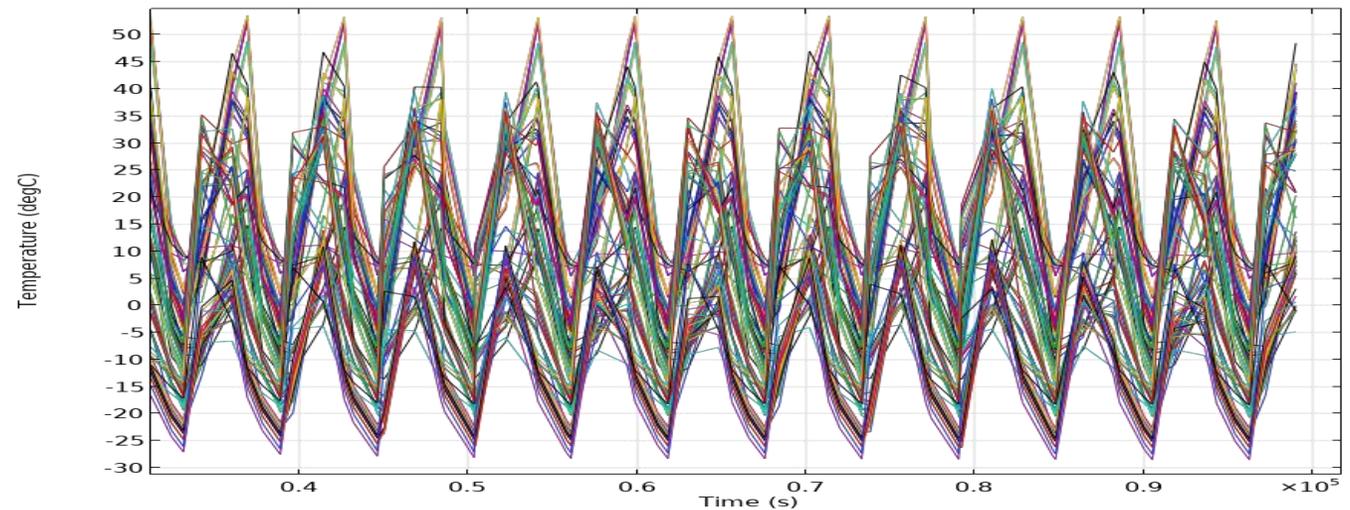
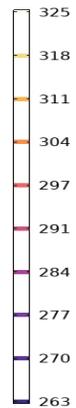
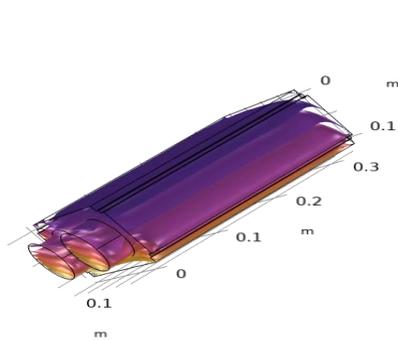


- Traveling more deep into space means the exposure to a wider range of temperatures. If we want to assure the readiness of the camera ,as an example, to work at all regimes and its operational limits are (-5 to 10 degrees C) then it requires conventional heat pipes for heat rejection at extreme hot conditions and heaters for heat addition at extreme cold.
- Double strokes solve both failure cases. The first stroke is a conventional heat pipe that rejects heat at extremely hot conditions. The second stroke uses another type of fluid (low heating power) which can be used to raise the temperature for extreme cold conditions. Second stroke can be used passively as a reversed heat pipe from hot to cold subsystems but if we consider a small camera traveling to deep space individually we have to provide the second stroke with heating capability.



- **Failure Case Analysis**

The honeycomb design for the same platform will require the application of more thermal control techniques due to higher predicted hot and cold spots in the given results. Temperature fluctuations for the same orbit are about -27 degC lower limit and more than 50 degC for higher limit which is a unworkable for camera operation.





- **Innovative Thermal Control Solution**

Two designs for double strokes heat pipes are given(Oval and U-shaped). Both are circular design form Aluminum 6061 and working fluid is ammonia for cooling stroke and butane for heating stroke.

