**For convection thermal modeling**

A **CFD analysis** was conducted with a fluid subdomain occupied by air defined between 2 boundary conditions.

The **2 boundary conditions** were:

**-The exterior surface of the internal assumption cylinder used to represent the caddy:**

-- The material of this cylinder was ABS plastic

-- Wall Heat Transfer Coefficient was defined as 500 W/m^2/K to exaggerate any effects that heat flow would have on the motion of the air within the fluid subdomain.

**- The interior surface of the external assumption cylinder used to represent the core casing:**

-- The material of this cylinder was 6061-T6 (SS)

-- Wall Heat Transfer Coefficient was defined as 500 W/m^k/K for same reason as before

The fluid subdomain consisting of dry air had particles given a stationary starting velocity of 0/0/0 with respect to the x/y/z axis. Pressure of the air was defined at 101352.9 Pa and its temperature defined as 294.2611 K, approximately that of the temperature of the caddy assumption cylinder. Turbulence intensity was defined to be 2% with a length of 0.00042164 m.

**AssumptionModelCFDAirSubdomain.png** in the project directory has the image of the result of air molecule trajectories calculated from this CFD analysis. **They were found to have negligible velocity**, as is expected with **no forced convection elements and symmetrical caddy/casing design.**

**AssumptionModelCFDAirTempGradientIsolines.png** and **CutPlot1.png** in the project directory has the image of the air temperature gradient as distance from the exterior surface of the caddy assumption cylinder increases, consistent with the thermal conduction properties of air within a fully defined fluid subdomain. **At the surface of the caddy assumption cylinder, the air molecule temperature is 294.2611 K, and at the interior surface of the core casing assumption cylinder, the air molecule temperature is approx 230 K.**

Since thermal differential between caddy assumption cylinder exterior surface and casing assumption cylinder interior surface have negligible effect on the molecular velocity of the air within the fluid subdomain, a thermal convection template via air was created using equilibrium conditions at interfaces and air equilibrium temperature of 247.0389 K to be used in thermal simulations.

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**This CFD analysis was then used in a thermal simulation.**

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A **transient thermal transfer calculation over 42 minutes** was performed using the data regarding air molecule trajectories and thermal gradients computed from the CFD analysis.

Configuring the simulation initial conditions to worst case scenario values comprised of the following:

* The heat flux at the caddy/air interface was defined to be 15 W/m^2
* The heat flux at the casing/air interface was defined to be 15 W/m^2

Transient time was defined to be 2520 seconds, or 42 minutes, as that is the duration of time that the satellite is in the shade.

For the first thermal simulation, with the caddy assumption cylinder initially set to 70 degrees Fahrenheit, the core casing assumption model locked at -100 degrees Fahrenheit, a total of 6.1608E-12 Joules of thermal energy is transferred to the core casing via convection through the air during the time the satellite is in the shaded portion of its orbit, approx 2520 seconds, or 42 minutes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Casing T (Farenheit)** | **Caddy T**  **(Farenheit)** | **Time**  **(Seconds)** | **Transfer**  **(Joules)** | **Direction** |
| **-100 L** | **70 UL** | **2520 s** | **6.1608E-12 Joules** | **Ca to CC** |
| **-100 L** | **30 UL** | **2520 s** | **8.4621E-12 Joules** | **Ca to CC** |
| **-100 L** | **-15 UL** | **2520 s** | **1.5183E-12 Joules** | **Ca to CC** |
| **70 L** | **-100 UL** | **2520 s** | **5.4865E-12 Joules** | **CC to Ca** |
| **30 L** | **-100 UL** | **2520 s** | **5.4865E-12 Joules** | **CC to Ca** |
| **-15 L** | **-100 UL** | **2520 s** | **5.4865E-12 Joules** | **CC to Ca** |

**6.1608E-12 J / 2520 s**

**= 6.1608E-12 Joules / 0.7 Hours**

**= 8.8011E-12 W / hrs**

**Convection can be ignored**

**For conduction**

* **Find out type of metal used in header pins**
* **Core casing is 6061-T6 Aluminum**
* **Use total pin surface area number (Model it as a square)**
* **Picture conduction as 1 metal block of 1 temp pressed against another block of temp 2**
* **Set one surface to -100 degrees F, the other to 70 degrees F (Worst case scenario)**
* **Find out in joules amount of energy transfer between plates over 1 minute**
* **(Between 0.002 and 0.5 is reasonable)**

**Conduction:**

[**https://www.eevblog.com/forum/eda/header-pin-hole-diameter/**](https://www.eevblog.com/forum/eda/header-pin-hole-diameter/) **(pin SA (0.64mm^2) references )**

[**https://blog.samtec.com/post/comparing-base-metals-connectors/**](https://blog.samtec.com/post/comparing-base-metals-connectors/) **(brass)**

**https://www.electronics-cooling.com/2001/05/the-thermal-conductivity-of-unfilled-plastics/**

**Thermal conductivity of:**

**Brass = 109 W/(mK)**

**Al = 167 W/(mK)**

**ABS plastic = 0.17 W/(mK)**

[**https://electronics.stackexchange.com/questions/77910/standard-length-of-male-header-pins**](https://electronics.stackexchange.com/questions/77910/standard-length-of-male-header-pins)

**Pin length L ~= 0.435’’ = 11.049mm**