Thermal Design

The purpose of the thermal design is to maintain all satellite components within allowable temperature limits for all operating modes of the vehicle when exposed to the thermal environments in the cosmic space. Due to the absence of atmospheric convection in space, overall thermal control of a satellite on orbit is usually achieved by balancing the energy emitted by the spacecraft as infrared radiation against the energy dissipated by internal electrical components plus the energy absorbed from the environment, as illustrated in **Fig.1**. The overview of these different types of environmental heating is as follows:

(1) Solar radiation: Sunlight is the greatest source of environmental heating incident on most spacecraft. The intensity is approximately 1358W/m^2.

(2) Albedo: Sunlight that is reflected off of a planet or moon is known as albedo. The energy is approximately 30 percent of solar radiation.

(3) Earth radiation: The earth not only reflects sunlight, it also emits long-wave IR radiation. The earth, like a satellite, achieves thermal equilibrium by balancing the energy received from the sun with the energy re-emitted as long-wavelength IR radiation. The intensity is approximately 237W/m^2.

(4) Radiation to space: The intensity depends on the temperature and surface aria of the satellite, radiation rate and so on.

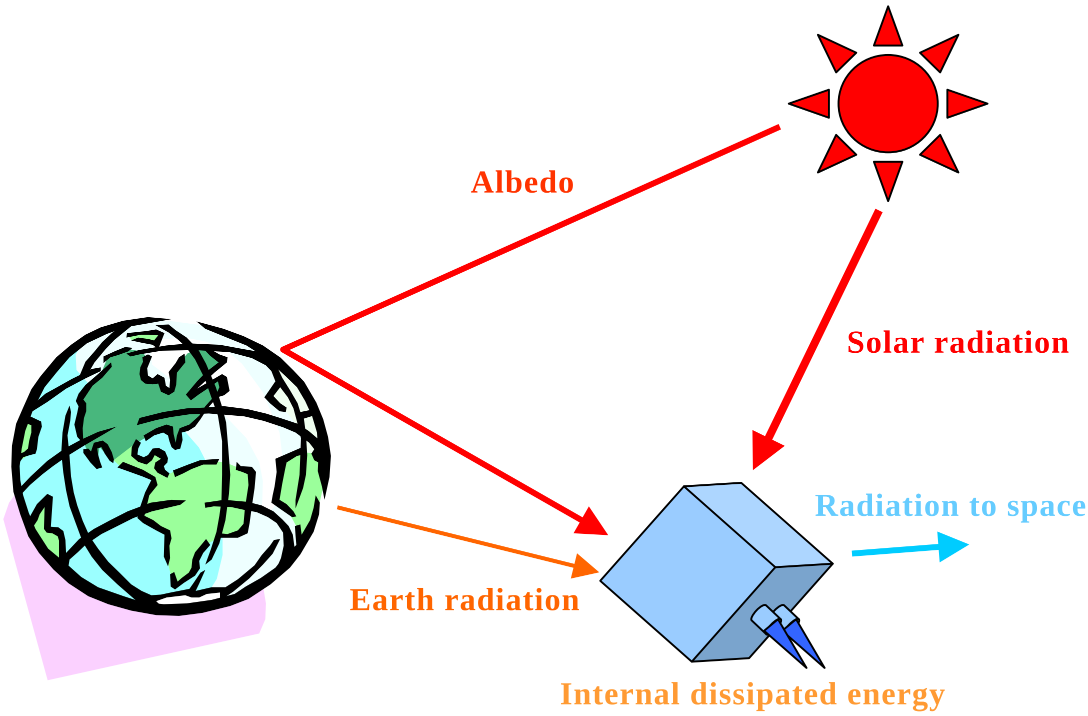


Fig.1 Satellite thermal environment.

Using the ANSYS code, the finite element analyses are carried out to estimate the temperature distribution of the satellite. First of all, it is necessary to check the accuracy of the FEM analysis. Thus, we compare the result obtained from the FEM analysis with one from the simple theory. We used the following formula by simple theory to obtain the temperature T of the satellite.

$$T = \sqrt[4]{\frac{A_s \times \alpha \times P_s}{A \times \varepsilon \times \sigma}}$$

where A and A_S are surface area and projection area, P_S is power of energy radiated for an object, α is absorption coefficient, ε is emissivity, and σ denotes Stefan-Boltzmann constant $(5.67 \times 10^{-8}\ \mathrm{W/m^2K})$. The results by this formula are available for the cases for no-temperature distributions in the satellite. And by using ANSYS, we calculate the temperatures of the analytical model shown **Fig.2** after 1.0×10^5 seconds with following physical properties.

Power of solar radiation	$1358\mathrm{W/m^2}$
Thermal conductivity	$1.93 \times 10^{12}\ \mathrm{W/mK}$
Specific heat	0.864J/kgK
Mass density	$2790\mathrm{kg/m^3}$
Absorption coefficient	1.0
Emissivity	1.0
Outer temperature	0K
Initial tempertures	100,200,273,300K

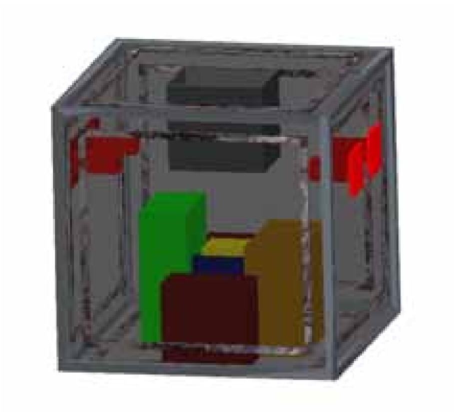


Fig.2 Analytical satellite model.

Figure 3 shows the ANSYS results. The temperature increases or decreases with increasing the time, and the temperature approaches 253.6K as time to infinity. The temperature obtained from the simple theory is 253.6K. The theoretical values and the ANSYS results are almost identical, meaning the ANSYS data are reliable. Therefore, we will further our research by using ANSYS in order to develop more sophisticated satellite models and their flames.

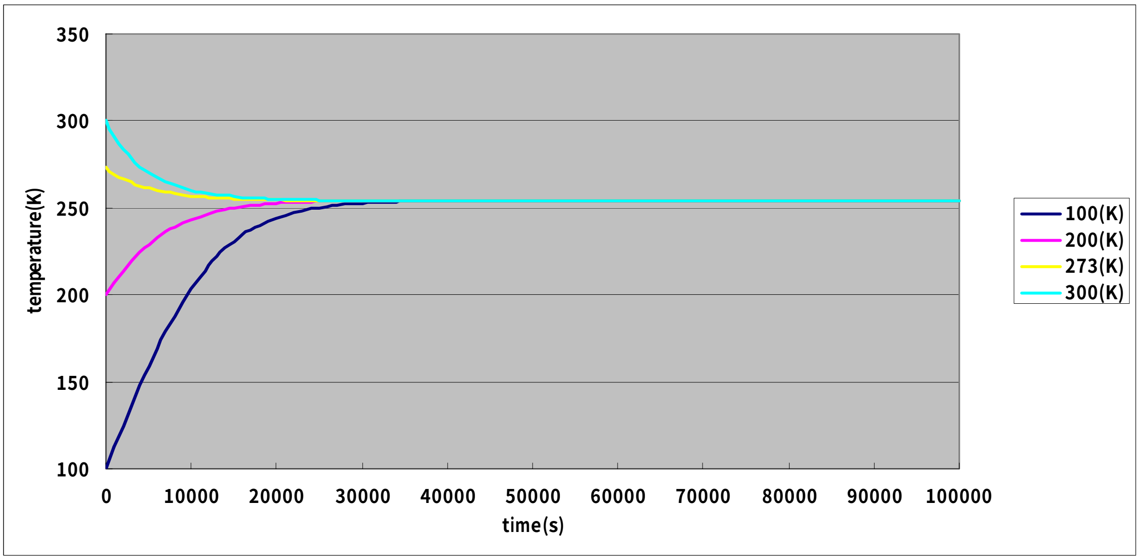
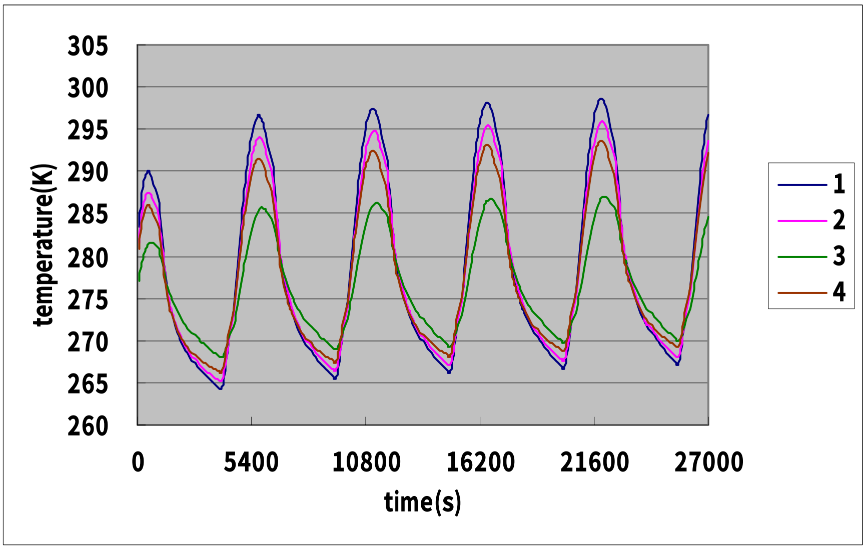


Fig.3 Temperature of the satellite vs. time (ANSYS).

We do not go into details and will show the results for the more sophisticated satellite model only. **Figure 4** indicates the variations of the satellite temperatures change that is a part of the numerical calculations.



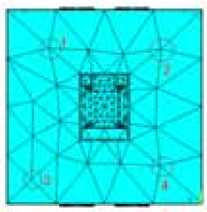


Fig.4 Variations of the satellite temperature.