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THERMAL ANALYSIS FOR A LANDER ON MARS SURFACE

Abstract

After launched on Mars surface, a lander will face a thermal environment with convection, radiation, and conduction coupling together. So Mars lander's thermal state will differ a lot from common satellites. These differences will lead to a series of new problems in thermal analysis and design of a Mars lander. From the literatures about the Mars, we can get the basic information of its thermal environment. Around 20 degrees north latitude on Mars, the surface temperature waves from 173K to 263K, wind speed changes acutely from 1 to 14m/s, and the pressure of the carbon dioxide atmosphere is about 700Pa. Based on some landers' structure, the lander model studied here is a close flat column, with a metal shell and an aerogel heat insulation layer inside. First we computed the heat losing power at a given temperature level, so the overall energy requirement was determined. As the Mars surface temperature rising, the heat losing power decreased. Under a surface temperature of 173K, the heat losing power is about 20W, at a surface temperature of 263K, the value is about 6.9W. Next we studied the influence of some factors such as Mars surface/air temperature, wind speed, day or night state, and heating power. The results showed that, the inside temperature changed linearly with the Mars surface temperature with a constant heat power. The wind speed affected the lander's temperature at the same time. Following these works, we paid attention to the heat insulation performance of the aerogel layer. The layer's effective thermal conductivity was changed from 0.01W/m.K to 1W/m.K, while the inside temperature dropt about 10K both in day and night. Finally the influence of atmosphere's component and pressure were studied. When the pressure changed from 700Pa to 0.1MPa, the convection heat transfer outside the lander was enhanced, and the inside temperature dropt about 20K. If the pressure was constant, the air changing from carbon dioxide to earth air could lead to a temperature drop of about 8K. These works showed that, the periodical change of environment temperature was the main affecting factor of the lander's temperaturewhile the wind speed was a weaker one. The temperature range of the lander differed a little from day to night. The total heat insulation performance of the lander was important to its temperature level, so more attention should be paid to reduce the heat leak from the heat insulation layer.