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A DEVICE FOR MEASURING HEAT FLUX ON A ROCKET SKIN SURFACE

Abstract

A novel method for measuring heat flux on a surface is presented. It is an extensive upgrade of currently known heat flux sensors used mostly in civil engineering. As the thermal environment of launchers, especially sounding rocket can have an enormous negative effect on payload, careful considerations have to be taken in the process of preparing insulation. Usually, thermal data provided by the launch vehicle manufacturer is limited only to temperature ranges, sometimes time plot. However, temperature is a very local phenomenon, and depends heavily on multiple factors such as launch configuration, insulation material, convection coefficient, air pressure, etc. Technical standards such as ECSS-E-HB-31-03A – Thermal analysis handbook incourages to perform thermal Coupled Launch Analysis (CLA) prior to launch. Access to precise boundary conditions is limiting verification of such results. The heat flux density on rocket skin varies greatly during course of flight, as the vehicle traverses layers of atmoshpere of various density with various velocities. Furthermore, it is difficult to determine the vector of heat flow a priori. These problems are handled in the design of new heat flux sensor. Due to special design, a 1D homogenous heat flow is enforced which allows easy model estimation and simplifies future calculations. As a result, no complicated finite element analysis is required and apparent heat flux density values can be calculated in real time by a simple embedded system with little computation power. A crucial element is dimensioning the sensor to match the launcher. The most important criteria are proper range of measurement (no saturation) and appropriate sensivity. The physics of the sensor has been carefully examined by various means including: analytical calculations, finite differences model and finite element analysis. The results of these calculations are verified with flights on AMBER and REXUS rockets. The device has a commercialization purpose for any launcher. The data it provides enables for more precise design of future payload, such as insulation thickness optimisation or material choice. Preliminary results from sounding rocket flights will be presented.