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A PREDICTIVE THERMO-ORBITAL MODEL FOR ANALYSIS OF SUN SYNCHRONOUS ORBITS OF NANOSATELLITES

Abstract

Passive control systems largely govern thermal control in nanosatellites due to structural constraints. Under such conditions, numerical estimation of heat flux, shadow function and internal heat dissipation are integral to the overall thermal control. Differential Equations that describe orbital trajectories are complex while accommodating Keplerian elements. This paper replaces the governing differential equations with simplified algebraic models. The relative orbital position of the satellite, with respect to the Sun and Earth, is estimated using Keplerian elements, thus constituting the Beta angle and in turn,estimating the Direct Solar Irradiance (DSI) as a function of time. In order to obtain heat flux information for a year on each face of the satellite, orthogonal transformations are used to amalgamate the orbital plane with heat influx on each face of the satellite on any given day considering direct solar irradiance, albedo, background infrared radiation and eclipse angles as a function of orbital position and solar day. This forms a foundation for a predictive model that generalizes orientation of the orbital plane with respect to the sun assuming no solar flares and eruptions. These heat flux functions obtained on all faces of the satellite are averaged in order to determine the total heat functional (depending only on a solar day) and then maximizing and minimizing the function to estimate extreme hot and cold cases respectively. Depending on the total heat function, the placement of solar panels on the satellite, to maximize the power generated and plausible deployment of solar panels, are determined. The shadow region of the satellite with respect to DSI is evaluated, and further determines the placement of the sun sensors such that the DSI constantly illuminates at least one sensor. From the results mentioned above, thermal cycling effects for AL-6061-T6 is estimated, including the non-linear radiation effects of the dynamic thermal-structural coupled system, for a period of 150 orbits in extreme cases using commercial FEA package. Then, an Auto-regressive integrated moving average(ARIMA) model is used to predict the thermal stresses for an extended period correlating with the beta angle.