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THERMAL INSULATION FOAM FOR THE HIGH PRECISION THERMAL MODELING OF SPACE SATELLITES

Abstract

It takes a lot of time to reach the high accuracy of the thermal model for the space satellite. We have to make a large number of procedures to validate the model. The heat transfer by radiation gives a sufficiently large error. If we take it into account without significant simplifications, it requires the determination of surfaces' optical properties and the enormous computing power of a computer. A proposed solution simplifies the spacecraft's thermal simulation by using polyurethane foam, which is filled into the spacecraft's inner space. With this approach, there is a possibility of local overheating of components that used radiation to dump heat on neighboring components. However, if we establish copper thermal sinks, their behavior is more predictable and easier to model. As a result, we get a spacecraft with a high-precision thermal model.

The problem with the use of thermal insulation foam is the uniformity of the spray and the curing of the foam. Studies have been carried out on the influence of atmospheric parameters on the uniformity of foam hardening. Tests were conducted for high and low pressure. Based on these tests, an efficient foam coating method was developed. At low pressures, a very long foam cure time was observed and maximum foam homogeneity was achieved. Heat loss and the main thermal characteristics for this method of insulation for these tests were calculated.

The proposed approach was applied to the developed CubeSat 3U of our Space Center. Thermal vacuum tests were carried out for a classic satellite structure and filled with thermal insulation foam. The thermal model of the second one corresponds to reality by more than 50

In a quantitative study of thermal bridge's thermal conductivity, there is a problem with thermal insulation. To decrease thermal lossless researchers use ceramic heat insulators, which fulfill their function but have a limitation in geometry.

We designed a test stand where we implement polyurethane foam. First, thermal conductivity and thermal resistance characteristics make it possible to use this material for conducting quantitative tests. Secondly, spraying, the application method, allows insulating any, even the most complex geometric shapes that could not be thermally insulated with ordinary thermal insulation coating.

In total, the proposed approach is applicable for satellite design and managing thermal control.