

Numerical analysis of the Thermal Control System for the K'OTO nanosatellite

Dafne Gaviria-Arcila, Jorge A. Ferrer-Perez,

Rafael G. Chavez-Moreno, Carlos Romo-Fuentes, Jose A. Ramírez-Aguilar

Over the last few years, there have been an increase of development of small satellites such as CubeSats. The development of this kind of spacecrafts is faster and cheaper than normal satellites fostering universities to create educational resources and train new professionals in space related technologies. The Advanced Technology Unit at the School of Engineering of the National Autonomous University of Mexico is developing a CubeSat called K'OTO. The K'OTO CubeSat has the mission of take photographs of low-medium resolution over the Mexican territory and transfer it to the earth on the ham band.

During the design and development of K'OTO surged the need to propose a thermal control system to ensure that the satellite's subsystems will operate within the operational temperature limits. Recently, the heat dissipation of satellite internal components has increase due to miniaturization. Therefore, the thermal control system play an important role for the heat dissipation of high-power systems.

The aim of this research is proposing a thermal control system for the K'OTO satellite and determine if is required use an active thermal control system such as heat pipes.

The thermal control system for the K'OTO CubeSat is analysed with numerical simulations and a parametrical study. The numerical analysis is performed using a finite element analysis scheme. ANSYS Thermal is used as a first approach, and the results will be compared against an analysis using Thermal Desktop to ensure that boundary conditions of the space environment are implemented adequately.

The main purpose of the numerical analysis is to determine which critical components are not within the operational limits. Thereafter, a passive control system will be proposed, and it will be analysed to review whether the satellite internal components meet the thermal requirements. Then, in case that the components exceed the operational limits using the passive control, an active thermal control system will be proposed.

Currently the project is in development. The main results show that the critical components which overpast the operational temperature limits are the components of the On Board Computer (OBC) and the Altitude, Determination and control Systems (ADCS). Therefore, on the next stage of the analysis We will investigate if the satellite requires the use of heat pipes to dissipate the thermal power energy from these components.

The next step of the research project is performing thermal testing to validate the numerical results. There are two tests to perform, the vacuum test and the thermal vacuum test. The tests will be done in the National Laboratory for Space and Automotive Engineering (LN- LINGEA) which is located at the Advanced Technology

Unit of the National Autonomous University of Mexico. The LN- LINGEA have a thermal vacuum chamber and the tests will be done according to the Norm ISO 19683.

The last stage of the project is to compare the numerical and the experimental results with the data obtained from the satellite in orbit. The K'OTO CubeSat is planning to launch with the JAXA from the ISS for 2022. The deliverables and results of the present project will help to the creation of Mexican standards and methodologies related with space exploration. This research is part of an unprecedented mission which will be like a spearhead of the Mexican Aerospace race because it will be a great contribution for technology independency that the country is looking for.

It is worth to mention that this project will impact the development of CubeSats in Mexico because the K'OTO CubeSat is one of the initiatives of the country to generate knowhow on the space sector. The development of Mexican space sector is one of the top national priorities because enhance the economic growth and provide the well-being of the population such as national security, digital inclusion, equity, education, among others. The space sector is one of the main opportunities areas in Mexico as a diversification of the economic growth of the country after the pandemic due to COVID-19. Because of that, one of the Mexican strategies to develop the space sector is the formation of highly qualified human capital which is one of the goals of the development of nanosatellite K'OTO. Moreover, this project is of great relevance since it is aligned with one of the sustainable development objectives established by the UN, which is to guarantee quality education and promote learning opportunities for all.