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DESIGN OF ANTENNA AND THERMAL ANALYSIS OF 2U-CUBESAT STRUCTURE USING AA-7075

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ABSTRACT: *A suitable communication antenna as per the CubeSat standard is considered for QB50.The design and deploying mechanism is modelled with a suitable mechanical design to incorporate the deployment of antennas. A CAD model of the Cubesat structure and their assembly are made using modelling software. This CAD model is subjected to Thermal analysis using analysis software to ensure that the CubeSat withstands the thermal conditions while in space. The Thermal simulation analysis provides information on the performance of the CubeSat at different thermal environments.*

Keywords **-** *CubeSat, antenna, antenna deployment, berylliumcopper, thermal analysis, von mises stress.*

1. INTRODUCTION

QB50 project consist of 50 CubeSats that will be launched in the first half of 2015 by a single rocket named Shtil-2.1, from Northern Russia (Murmansk) into the earth orbit of 320 km altitude and inclination of 79 º. The 2U CubeSat will carry a set of standardized sensors with cutting edge technology, long-duration measurements to collect scientific datas of unexplored layers of lower thermosphere and ionosphere.

The existing methods for antenna deployment mechanism have been analysed, then a simple and most effective mechanism has been modelled by design software. Suitable materials, dimensions for antenna and sub – assemblies have been applied. Then the software analysis for survival of antenna and their assemblies under deformation and effect on stresses have been analysed.

2. METHODOLOGY

The 2U CubeSat which have to be considered for analyzing and the process methodology is as shown in Fig 1.

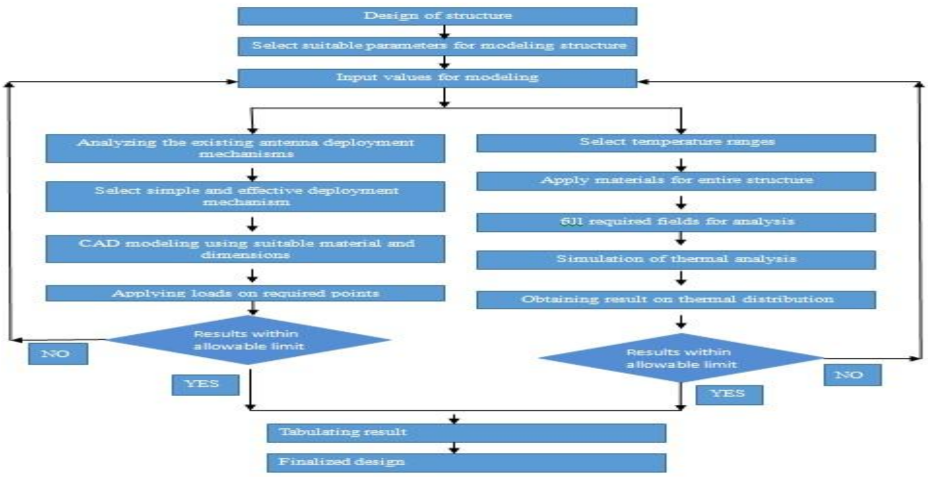

Fig 1 methodology

For QB50 a suitable Antenna must be designed to transmit the required uplink and downlink frequency also a suitable material for antenna and antenna deployment mechanism must be designed to deploy antenna at the time of ejection. The total setup must be within the limit of 100 grams as per the specified mass. The CAD model has been designed using SOLIDWORKS modeling software and temperature analysis is done under various configurations using same software.

The loads experienced during launch by satellite will be critical than any other time during its lifetime. It is necessary to simulate the behavior of the structure during the takeoff. The loads will differ depending on the launch vehicle; hence analysis is conducted in order to find the maximum and minimum stresses and displacements.

The entire structural design of CubeSat tested under various thermal patterns with modified parameters to withstand temperature fluctuation at the time of launch, eclipse region in space and at the time of satellite acing the Sun. By calculating the temperature distribution and its fluctuation range, the whole structure is fobserved to withstand the temperature fluctuation.

3. COMPONENTS OF SATELLITE’S ANTENNA SYSTEM

The major components of antenna deployment mechanism are listed in table 1.

S.No	Card/ Subsystem
1	Antenna
2	Antenna holder arms
3	Springs
4	Antenna setup base
5	Antenna setup top
6	Bolts and nuts for antenna holder
7	Bolts and nuts for antenna setup
8	Nicrome wire strip
9	Nylon strip
TOTAL MASS LIMIT = 100 grams	

Table 1 Components of the Antenna deployment mechanism

4. DESIGN CALCULATIONS

ANTENNA DESIGN:

QB50 project requires the use of 145 MHz uplink for 1.2Kbps and 435 MHz downlink of 9.6KBps data for communication to ground station. The length of antenna is calculated by taking ratio of wavelength to frequency. The wavelength is 300Mm/s. The velocity is slightly lower on a wire compared to air, which is about 98%. Material used for Antenna is Beryllium-copper.

The UHF frequency is 435 MHz So antenna length = 300 / 435 = 0.6896 metres; considering quarter wavelength. Then antenna length = 0.6896 / 4 = 0.1724 meters

5. ANTENNA DEPLOYMENT MECHANISM

The antenna is put against the spring pressure, which is locked using nylon wire strip. A simple Nicrome melting nylon mechanism is incorporated to deploy the antenna once voltage is supplied. The nylon cuts in half under the temperature produced by nicrome which releases antenna at the required time. The fig 2 & fig 3 shows the setup of antenna deployment mechanism.

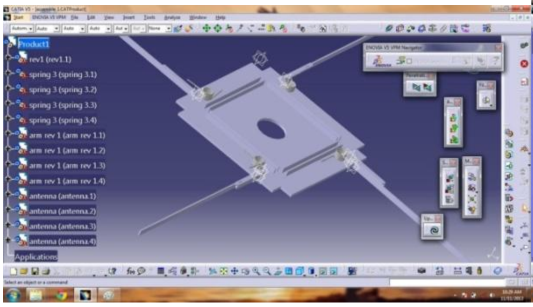

Fig 2 setup base

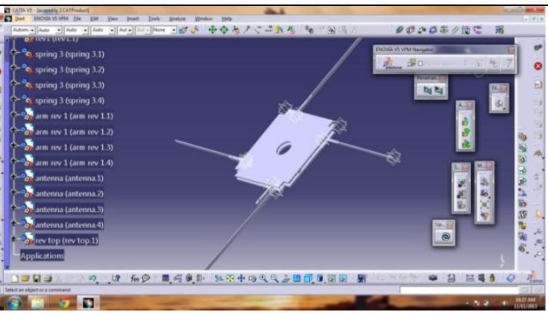

Fig 3 antenna deployment full setup

THERMAL ANALYSIS

The software used for Modelling and Analysis of Thermal patterns is SOLIDWORKS. The thermal analysis is done considering various parameters such as radiation temperature, eclipse temperature, duration for thermal cycling and thermal properties for every individual material. The most essential thing is that the communication and scientific components of the satellite may not exceed apart from the operating temperatures.

The VHF frequency is so Antenna length = (300 / (145*4)) = 0.5172 meters

6. RESULTS AND DISCUSSION

ANALYSIS OF ANTENNA:

The meshing and analysis of antenna is done using CATIA software. Total nodes of 555 and DOF of is 1667. The number of factorized degree is 1611. Strain Energy is $6.844e^{-14}$ Joules. Von-Mises stress: Min to Max = $2.34e^{-11}$ to $49.4e^{-11}$ N/mm^2.

Value	Dof	Node	x (mm)	y (mm)	z (mm)
3.6319e+002	Tz	260	1.1381e+002	2.0000e+000	5.0000e-001
2.6948e+009	Tz	236	4.5857e+001	-2.1316e-014	5.0000e-001

Table 2 Minimum and maximum pivot

The fig 4 shows the deformation of antenna under load, and fig 5 shows the pattern of von mises stress induced at the time antenna deployment. Both results show that the antenna is within the safer limit.

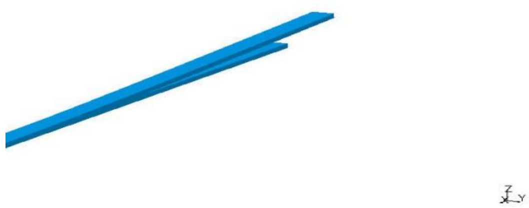

Fig 4 - Deformation of Antenna

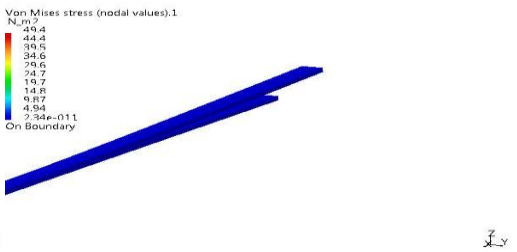

Fig 5- Von-Mises stress of Antenna

THERMAL ANALYSIS OF STRUCTURE:

After doing thermal analysis by varying several parameters such as temperature, thermal properties and thermal cycling time the structure ensures the minimal change in temperature for communication boards. Which means it is possible for the essential telecommunication parts to operate under safer limits.

Several combination of temperature values have been used for thermal analysis. A thermal analysis result is shown in fig 6 & 7 considering Radiation temperature as 110 ˚C and Initial temperature as 40 ˚C shows the Temperature rise in communication boards have less influence of temperature at thermal cycling.

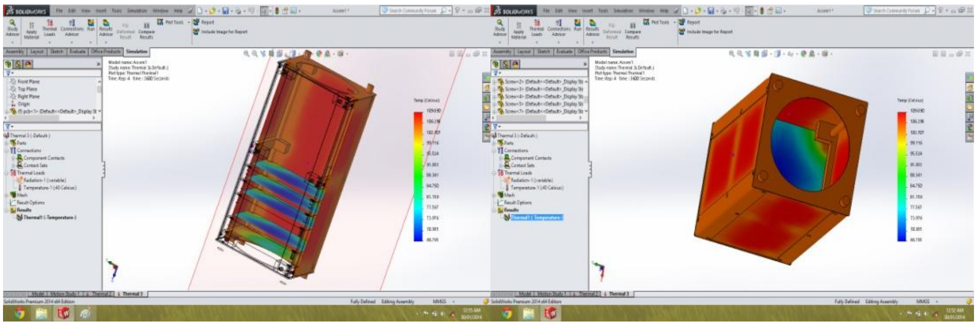

Fig 6 & 7 Thermal analysis results showing less heat affected in communication boards

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