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Manufacturing and Stress Analysis of GFRP and CFRP V-Sat Antennas

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Abstract: *Information technology has become a very vital tool in the world today. Satellite communication was developed around 1958 to later enhance communication strategy using different earth stations made of very small terminals called V-SAT which can transmit and receive signals from spacecraft satellite via the internet. V-SAT is a type of parabolic dish antenna. The standard specifications of V-SAT Antenna are 5.5-15m hub and 1.2-3.5m diameter.This project deals with the Modeling, analysis and manufacturing of V-SAT antennas. Modeling of V-SAT antennas is made as per the standard specifications using Unigraphics CAD software. Structural analysis on antennas is also done for various wind load using ANSYS CAE software. The materials used to make the V-SAT Antennas are Eglass/Epoxy and Carbon/Epoxy.The results obtained for both materials are compared. Hand lay up technique is used to manufacture V-SAT Antennas with composite materials. Profile accuracy of antenna also determined by making use of templet. Specimen of the composite used for making antenna are tested for flexural and shear stress.*

Keywords: *Carbon/Epoxy, Eglass/Epoxy, Hand layup techniques, V-SAT*

I. Introduction

V-SAT stands for Very Small Aperture Terminal and refers to receive/transmit terminals installed at dispersed sites connecting to a central hub via satellite using small diameter antenna dishes (0.6 to 3.8 meter). Traditionally, the satellite is a radio relay station that receives, amplifies and redirects analog and digital signals contained within a carrier frequency. These signals contain data, voice, and video communications. V-SAT systems can be configured for bi-directional or receive-only operation. In bi-directional operation, the dish both sends (uplinks) and receives (downlinks) the information for use in LANs.

A very small aperture terminal (V-SAT) is a two-way satellite ground station with a dish antenna that is smaller than 3 meters. The majority of V-SAT antennas range from 75cm to 1.2m.Data rates range from 4 kbit/s up to 16 Mbit/s. V-SAT's access satellites in geosynchronous to relay data from small remote Earth stations (terminals) to other terminals or master Earth station "hubs". This hub is usually very expensive and more difficult to maintain. From this hub, several smaller terminals can then be connected to, which serves as intermediary between the smaller terminals and the satellite. These smaller terminals are termed the V-SAT (Very Small Aperture Terminal). V-SAT is a form of small earth station which can transmit, receive signal to the satellite via the internet. This paper sets out to develop a way to build V-SAT dishes as supported by today’s technological advancement (i.e. building smaller size equipment that will still perform optimally for data signal transmission).V-SAT's are used to transmit narrowband data (e.g., point-of-sale transactions using credit cards, polling or RFID data, broadband data. V-SAT's are also used for transportable, on-the-move or mobile maritime communications.

1.1 Overview:

This section introduces and provides a brief description of the major components and factors that go into making a V-SAT system.

- Antenna
- Power Amplifier
- Up - Converter
- Down Converter
- Modulator
- Demodulator
- Low Noise Amplifier

II. Materials

The glass and carbon fiber rovings & mat's used for manufacturing of the V-SAT antenna was supplied by Advanced Millennium Materials pvt.ltd. The matrix material has a high quality, medium viscosity, medium reactive specially formulated for processes like Filament winding, spray up/hand layup. It exhibits good chemical resistance and possess superior mechanical and thermal properties. The resin has exceptionally good hydraulic resistance making it an ideal choice for coating / laminating applications. The ISO resin forms strong bond with fiber rovings and depicts good wet out characteristics due to good weathering properties and retention of glass& carbon suitable for corrosion resistant applications.

III. 3d Modelling of V-Sat Antenna

3d modeling of V-SAT antenna was done by using NX-CAD. NX-CAD is the world’s leading 3D product development solution. This software enables designers and engineers to bring better products to the market faster. It takes care of the entire product definition to serviceability. NX delivers measurable value to manufacturing companies of all sizes and in all industries.

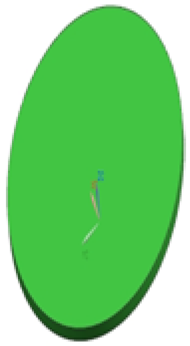

Fig 3.1: Isometric view-1

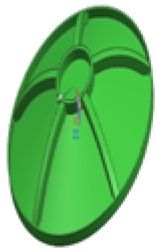

Fig 3.2: Isometric view-2

IV. Stress Analysis of GFRP And CFRP V-Sat Antennas

The analysis of the V-SAT antenna is done by using ANSYS 15.0. The model is to be imported from Uni graphics to ANSYS in the form of parasolid file. The wind load applied on the antenna. Displacement, stress and factor of safety were calculated for two materials.The following material properties are required for analysis of V-SAT antenna structure.

1. **Properties of E-glass/Epoxy material:**
   Young's modulus = 50 GPa
   Density = 2000 Kg/m3
   Yield strength =800 MPa

2. **Properties of Carbon/Epoxy material:**
   Young’s modulus = **134 GPa**
   Density = **1600 Kg/m3**
   Yield strength =**880 MPa**

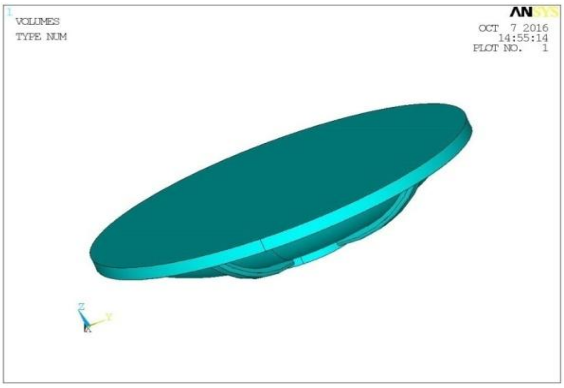

Fig 4.1: Infinite model of V-SAT antenna

Fig 4.2: Finite model of V-SAT antenna

3. Boundary conditions:

Wind(mph)	40	45	50	80	125	150
F (N)	373	471	582	1490	3638	5240

4. Stress Analysis Results of GFRP AND CFRP V-Sat Antenna

S.No	Material	Displacement(mm)	Von misses stress(MPa)
1	Eglass/Epoxy	0.07mm	37.74MPa
2	Carbon/Epoxy	0.009mm	24.82MPa

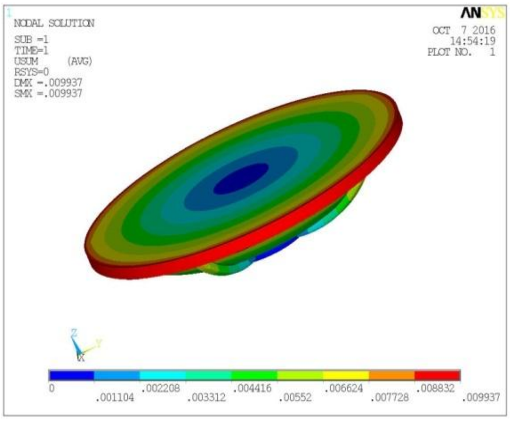

Fig 4.5: Total displacement of the CFRP V-SAT Antenna

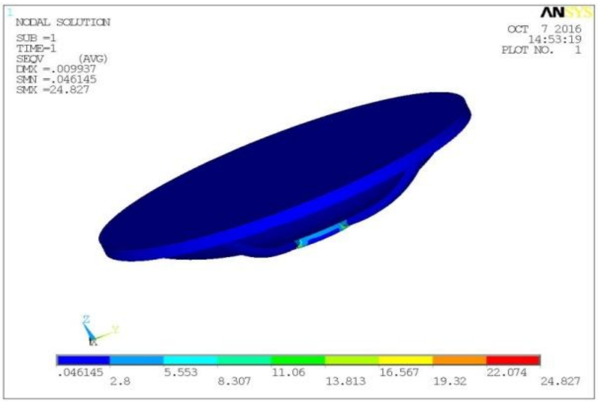

Fig 4.6: Von misses stress of the CFRP V-SAT Antenna

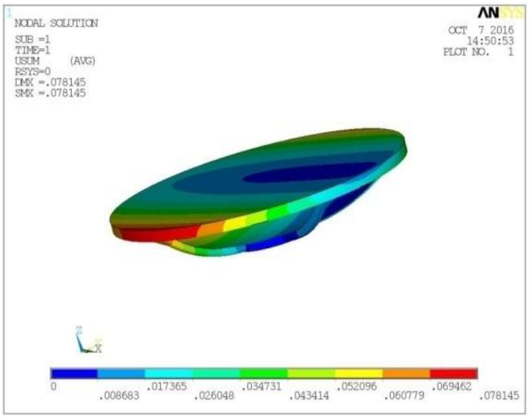

Fig 4.3: Total displacement of GFRP V-SAT Antenna

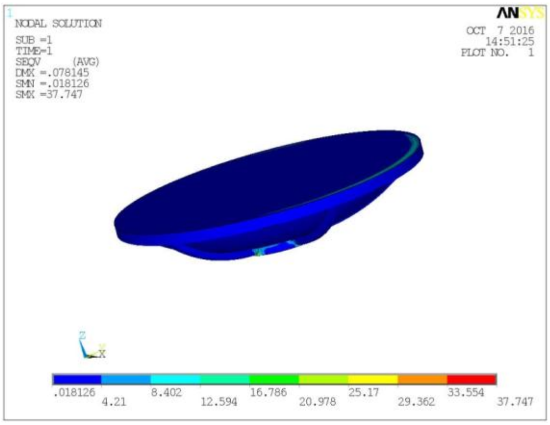

Fig 4.4: Von misses stress of GFRP V-SAT Antenna

V. Manufacturing Method

1. Hand Layup Technique:

V-SAT antenna's manufactured by using Hand layup Technique. Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mould surface to avoid the sticking of polymer to the surface.

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mould surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mould plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mould size and placed at the surface of mould after perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardner (curing agent) and poured onto the surface of mat already placed in the mould. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mould plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mould is opened and the developed composite part is taken out and further processed.

The time of curing depends on type of polymer used for composite processing. For example, for epoxy based system, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites. Capital and infrastructural requirement is less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, diase board, deck etc. Generally, the materials used to develop composites through hand lay-up method.

2. Steps Involved in Hand layup Technique:

- Preparing the mould.
- Applying the gel coat.
- Layup Skin coat.
- Laying fiber glass reinforcement.
- Trim.
- Cure.
- Remove part from mould.
- Finish

1. Preparing the mould for manufacturing: This is the first step of manufacturing of V-SAT antenna. This step involves removing the dirt and dust on the mould. Ensure the whether the mould is free foreign materials.

2. Applying of gel coat on the mould: A gel is sprayed on the mould surface to avoid the sticking of polymer to the surface. It is used for better finish of the part after manufacturing. In this process the gel coat takes around 30 minutes.

3. Layup skin coat: This step involves mixing of resin and curing agent in suitable proportion**.** This mixture is mixed thoroughly before poured on surface . This mixture is spread on the surface uniformly with the help of brush.

4. Laying fiberglass Reinforcement: This step involves laying of glass fiber Reinforcement (i.e. CSM) on the surface of the mould. Glass fiber reinforcement (i.e. CSM) in the form of woven mats or chopped strand mats is placed at the surface of mould. The polymer is uniformly spread with the help of brush. Roll a roller with a mild pressure on reinforcement to remove any air trapped as well as the excess skin coat present.

5. Trim: This step explains above removing of extra reinforcement on the edges of the mould. The extra reinforcement at the edges of the mould is removed by using knife.

6. Curing: After completion of trim step, the mould is cured at room temperature for few hours. After completion of curing, the above process is repeated for next layer.

7. Removing of V-SAT Antenna from the mould: This step is done after curing of the V-SAT Antenna. This step involves removing of V-SAT Antenna from the mould.

8. Finish: This is the last step of manufacturing of the V-SAT Antenna. This involves adding sand on the bottom of the part.

Fig 5.1: Applying of gel coat

Fig 5.2: laying of fiberglass reinforcement

Fig 5.3: strengthening of mould

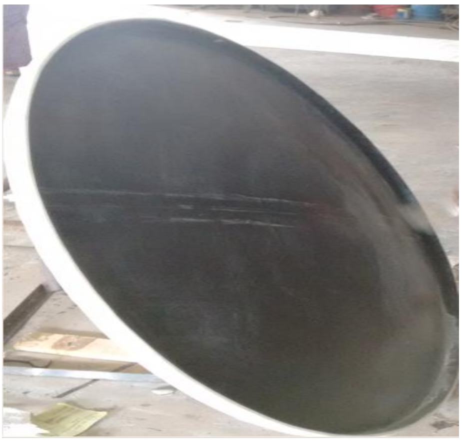

Fig 5.4: mould for V-SAT antenna

Fig 5.5: final product of V-SAT Antenna

3. Profile Accuracy:

Fig 5.6 : Templet for Mould and Final Product

Fig 5.7: Measuring deviations in the Profile

1. Measured the deviations by using filler gauge and note down the readings for each inch and calculated the root mean square value for the above readings.
2. The RMS value of a set of values is the square root of the arithmetic mean of the squares of the values, or the square of the function that defines the continuous profile. RMS Value is considered as Profile accuracy equals to 0.7 which indicates the parabolic reflector is accurate and smooth.

Applications:

- Airport flight and weather, data Emergency services, Electronic fund transfer at Point-of-Sale, military communications, Bank transactions, ATM, Interactive computer transactions, Stock market & other news broadcasting, Training or continuing education from a distance, Distribute financial trends & analyses, etc

VI. Conclusion

3D model of V-SAT antenna was modelled as per standard specifications by using NX-CAD software. V-SAT Antenna model was imported to ANSYS software to perform static analysis for wind load conditions. Static analysis of V-SAT antenna is performed for both E-glass/Epoxy material and Carbon/Epoxy materials. The following conclusions are made:

1. The displacement of V-SAT Antenna for Eglass/Epoxy material is more than the Carbon/Epoxy material.
2. The Von misses stress of V-SAT Antenna for Eglass/Epoxy material is more than the Carbon/Epoxy material.
3. When the stresses developed in V-SAT antenna compared with yield strength of composites,it is found that the stress values are very less.
4. The Both composite V-SAT antennas are safe under variable wind loads.
5. V-SAT Antennas production will be large scale in industries.The strength properties of glass fiber is nearer to the carbon fiber and Due to the high expensive of carbon ,glass fiber is used to manufacture the V-SAT antenna.Hence, It is concluded that V-SAT Antenna is manufactured by using Eglass/Epoxy material by using hand lay-up technique.
6. A Technique also proposed in this project to check the profile accuracy of parabolic reflector of antenna.

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