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Design and Analysis of Air Borne Radome

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ABSTRACT

Radom's are the electromagnetic windows that protect microwave sub-systems from the environmental effects. The major requirement of radome is its transparency to microwaves and for most of the cases mechanical properties are also equally important. Radome for underwater applications has to withstand high water pressure of the order of 45 bars. Composite materials owing to their high strength to weight ratio, high stiffness and better corrosion resistance are potential source for under water applications. The concept of 'tailoring' the material properties to suit the radome is obtained by selecting proper reinforcement, resin matrix and their compositions.

The mechanical properties of composite material, evaluated by testing specimens as per ASTM standards, are utilized in designing the radome. The modulus properties calculated using classical theories of composite materials and compared with test results. The theoretical values utilized to carry out the Finite Element Analysis of the radome. ANSYS a Finite Element software package used to analyze the problem. As the cross sectional thickness of radome varies, the complexity in fabrication is overcome by adopting matched die techniques. The radome design and finite element analysis validation concluded by conducting the pressure test on radome. The radome is also carried out modal analysis to check for the natural frequency of the radome. So that resonance does not occur if the natural frequency of the radome coincides with the excitation frequency of the submarine.

INTRODUCTION

composites are gaining wider acceptance for use on board warships and submarines due to number of advantages viz. high strength to weight ratio, ability to be moulded into complex shapes, better EMI performance, absence of corrosion palliatives which otherwise are source for electronic and magnetic signature. Composite materials made from E-Glass fibers and epoxy resins have become very popular as a radome material due to its outstanding transparency to microwaves and having good mechanical properties. The increasing popularity of the material for underwater application are posing great difficulties to the designer to select right combination of composition & shape of radome due to the complex nature of the structure and the loading conditions for the useful operation life.

Mechanical properties of composite materials are influenced by several factors like reinforcement, fiber orientation, adhesion, composition, manufacturing process etc. Conducting the tests on standard specimens and evaluating mechanical properties is the most important aspect in design of composite material applications. The ASTM guidelines followed in testing and preparation of standard test specimens. The micro-mechanics and failure mechanism of composite material is very complex compared to the conventional isotropic materials.

Finite Element Analysis of radome design is carried-out using (Analysis System) ANSYS a FEA software package. Geometrical model of radome is generated as per radome sketch. Suitable elements are selected and optimum size of mesh is generated. Material properties, evaluated from tests, are assigned. Boundary conditions, load cases are applied to complete the preprocessing stage. The post results obtained after FE analysis compared with design requirements.

The main objective of this project is to develop composite radome which protects the electronic equipment from high water pressure and transparent to electromagnetic waves. The geometric shape of the radome is a cylindrical barrel covered with a hemi-spherical dome at the top. It has a circular plate at the bottom end of the cylinder having M6 size holes which acts as a flange. The radome is secured to the submarine structure with M6 bolts on its flange. Radome is made of sandwiched construction with glass reinforced plastic (GRP) as sheet material and syntactic foam as core. E glass woven fabric & Epoxy resin is used

2.**LITERATURE SURVEY**

Although the name of the finite element method was given recently the concept has been used several centuries back. For example, Ancient mathematicians found the circumference of a circle by approximating it as a polygon. In terms of the present day notation each side of the polygon can be called a finite element, by considering the approximating polygon inscribed or circumscribed, one can obtain a lower bound or an upper bound for the true circumference. Further, as the number of sides of the polygon is increased the approximate values coverage to the true value, these characteristics will hold true in any general finite element application.In recent times an approach similar to the finite element method, involving the use of piece wise continuous functions defined over triangular regions, was first suggested by R. Courant in 1943 in the literature of applied mathematics.

The finite element method as known today has been presented in 1956 by M.J. TURNER, R.W. CLOUGH, H.C. MARTAIN & L.J. TOOP. This paper presents applications of simple finite elements (pin-joined bar & Triangular plates with in plane loads) for the analysis of aircraft structure and is considered as the key contributions in the development of the finite element method. The digital computer provides a rapid means of performing the many calculations involved in the finite element analysis and made the method practically viable, along with the development of high speed digital computers the application of the finite element method progressed at a very impressive rate.

The book by Przemieniecki, and Zienkievicz and Hoslister presented the finite element method as the applied to the solutions of the stress analysis problems. The book by Zienkievicz's and Cheug" the finite element method in structural and continuum mechanics" (Mc.graw hill, London, 1971) presented the broad interpretation of the finite element method and its applicability to any general field problems. With this broad interpretation of the finite element method it has been found that the finite element equation also be derived by using a weighted residual method such as Galerkin method or the least squares method.This lead to widespread interest among applied mathematicians in applying the finite element method for the solution of the linear and non-linear differential equations.

3.RADOME

3.1 Radome Phenomenology

A radome, an acronym coined from radar dome, is a cover or structure placed over an antenna that protects the antenna from its physical environment.Radomes are composed of panels, which when assembled form a truncated spherical shell. Ideally, the radome is radio frequency (RF) transparent so that it does not degrade the electrical performance of the enclosed antenna in any way.Today, radomes find wide applications in ground, maritime, terrestrial (ground), vehicular, aircraft, and missile electronic systems.

Radomes can be constructed in several shapes (spherical, geodesic, planar, etc.) depending upon the particular application using various construction materials

Radome design is uniquely challenging in that the performance parameters are generally in direct conflict with each other and the design must be iterated until all competing parameters are optimally satisfied. The design process is a compromise between electrical transparency and mechanical strength. There are many dielectric material options, each with their unique properties, including electrical properties, mechanical properties, environmental resistance, and cost. Finally, the radome design must be evaluated from a manufacturing standpoint.The increased power of modern computers allows a radome designer to evaluate designs in a manner that was not previously possible, such as designs with frequency selective materials, low observable treatments, or meta-materials.

Radome with antenna

3.2 Radome Dielectric Materials

In analyzing radome electrical performance, it is important to evaluate the electrical properties of possible radome wall materials at various wavelengths. The primary electrical properties of candidate materials are the relative dielectric constant and the loss tangent of the candidate materials at the operational frequencies of the radome.

The structural (aeromechanical) and environmental requirements determine other parameters for a candidate radome material and include:

- Mechanical properties, such as flexural moduli, strength, and hardness;
- Material density;
- Water absorption;
- Rain erosion (particle impact) resistance;
- The variation of both the mechanical and electrical parameters of the material due to temperature variations.

3.3 Radome Types

Radomes for use on flight vehicles (aircraft or missiles), surface vehicles and fixed ground installations are classified into various categories according to MIL-R-7705B [6]. These categories are determined by the specific radome use and wall construction.

There are six types of radomes as identified in the following sections.

3.3.1Radome Type Definitions

There are six types of radome definitions:

- Type I radomes are low frequency radomes and used at frequencies at or below 2.0 GHz.
- Type II radomes are directional guidance radomes having specified directional accuracy requirements. These include boresight error (BSE), boresight error slope (BSES), antenna pattern distortion, and antenna side lobe degradation.
- Type III radomes are narrowband radomes with an operational bandwidth less than 10%.
- Type IV radomes are multiple frequency band radomes used at two or more narrow frequency bands.
- Type V radomes are broadband radomes generally providing an operational bandwidth between 0.100 GHz and 0.667 GHz.
- Type VI radomes are very broadband radomes that provide an operational bandwidth greater than 0.667 GHz.

3.3.2Radome type based on wall construction:

- Half-Wave Wall Radomes (Style a)
- Thin Walled Radomes (Style b)
- A Sandwich Radome (Style c)
- Multilayer Radomes (Style d)
- B-Sandwich Radomes (Style e)

a **b**

c

(A) Ground based radomes
(B) Shipboard radomes
(C) Solid laminateradomes

3.4 Shape Considerations

Rationale for Choosing a Particular ShapeCommon radome shapes include, but are not limited to the following:

- Hemisphere;
- Secant ogive;
- Tangent ogive;

From an electrical viewpoint, a hemisphere is most desirable because of its very small incidence angles resulting in small electrical degradations.

3.5 Functions of the radome:-

The Functions of the radome are as follows:

- The radome protects the installation from the deteriorating effects of environment and extends the durability of antenna and other equipment.
- The overall performance of the antenna will be increased with the use of radome.
- A radome helps to have overall economy and weight reduction.

- A radome permits the air borne antenna to function with good efficiency under high head of the water over the submarine.

3.6 Fabrication Methods for Radomes

The selection of a manufacturing method for a given Radome design may be based on a number of factors including the Radome performance requirements and the materials of construction. For example selection of a fabrication method for a Radome often starts by the consideration of Vacuum bag or Autoclave moulding using glass fabric reinforcement. Frequency requirements for maintaining uniform electrical properties in the Radome wall might eliminate the less expensive fabrication methods and dictate a filament winding approach whereby this control is more readily accomplished.

3.6.1 Filament winding:

A major advantage of the filament winding process is that it lends itself to automated equipment. Even more important advantage is that it allows very close control of the resin to glass ratio, which results in a uniform dielectric constant throughout the radome. The ability to produce on a repeatable basis a radome wall of known dielectric constant makes it possible to machine or grind the radome wall to a given physical dimension thereby eliminating in many cases, the necessity for measurement of electrical wall thickness during the final grinding operation. Also the electrical testing and correction time required for the Radome is reduced when a uniform electrical wall is present. In addition, the filament winding process allows the orientation of the fibers in the primary directions of load, thereby providing structural design flexibility not possible with fabric reinforcements. The glass reinforcement plastics normally exhibit dielectric constants of the order of 3.5 to 4.5 at X-band frequency.

3.6.2 Vacuum Bag Moulding:

Vacuum bag moulding "wet lay-up" of glass reinforced plastic radomes is one of the earliest techniques employed. This technique involves laying down dry glass fabric, which is wet with the liquid resin during the lay-up operation. After the desired thickness has been obtained, a plastic film bag is placed over the lay-up, sealed to the mould and connected to the vacuum source, which evacuates the air between the plastic bag and the lay-up. The major advantages of this fabrication process are its relatively low cost and high quality laminate, which can be produced by skilled workers.The removal of excessive resin and air from the lay-up is performed by squeezing or wiping operation using a rubber soft plastic tool. This squeeze operation not the vacuum bag pressure, determines the final thickness and resin content at laminate.

3.6.3 Autoclave moulding:

The Autoclave moulding is similar to vacuum bag moulding in that the lay-up is sealed in plastic bag, which is evacuated by a vacuum pump prior to application of the autoclave pressure. Autoclave moulding of Radome is normally used with pre-preg materials, which do not allow squeezing to remove entrapped air, and with resin systems, which generate reaction products during cure. Unlike the vacuum bag process, the pre-preg lay-up is normally followed with a perforated plastic film or a glass fabric which been treated to prevent adhesion of the resin. This apparatus is followed by a lay-up dry bleeder material such as glass or other type fabrics which absorb the excess resin or reaction products or both which are eliminated from the part during the cure.Most Autoclave used in the fiberglass plastic industry have operating pressures between 100 and 200 psi and temperature capabilities upward to 500^{o}F resin systems such as diallylphthalate and most epoxies may be adequately. Systems such as silicones, phenolics, polyamides and polybenzidazoles are frequently moulded at pressures of the order of 200 psi. The higher pressure normally yields superior composites, provided a more reliable manufacturing process and assures greater reproducibility from part to part.

CONCLUSION

The main constrain of this project is minimizes of stress. To reduce this stress three methods had considered they are

- Design modification in existing model
- Material change in existing model
- Design modification and material change in existing model

In this process we took one 12mm Radom with **Epoxy-E-Glass** material and analyzed at high pressure condition, to reduce the stress values we increased thickness in modified design

In generally when we increase thickness we will get less stress but our model will increase its self weight so heavy weight also is not good for object

To reduce weight the we chosen **Epoxy-Carbon** material

By this modification we nearly reduced **65 mpa** stress and also reduced weight **500 grams**

And dynamic analysis we also calculated natural frequencies of models and all materials

The frequencies are high so our model is safe.

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