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Static Analysis of Parabolic Radome

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ABSTRACT— Radomes (Radar Domes) are characterized as electromagnetic windows, comprising of spreads or lodgings that serve to shield electronic hardware from effects of environment influences such as dust, wind and rain. The selection of materials and shape depend upon the radome application. In this paper, zirconia based ceramic material and silicone resin were used for the study. The design of radome depends on the several mechanical factors such as unpredictable outline, non-uniform pressure, non-isotropic materials, impact loads and thermal loads. In this study, a sandwich shaped multi-layered wall structure was modelled using CREO. Further, static analysis of radome was carried out under varying boundary conditions. In addition, thermal analysis of radome was analysed using Fluent. The results of the study are shows that zirconia based radomes have good performance over other materials.

Index Terms— Radome, Zirconia, Dynamic Analysis, Thermal stress distribution.

I. INTRODUCTION

A Radome is a structural, weather proof shield that protects an antenna. The radome is made of fabric that minimally attenuates the magnetic force signal transmitted or received by the antenna. In different words, the radome is clear to radar or radio waves. Radome defends antenna surfaces from weather or conceals antenna equipment from public read. They conjointly shield close personnel from being accidentally stuck by quickly rotating antenna. Antennas are used mainly for handheld, ship-borne and land-based applications. In both of these applications, the corresponding antenna is exposed to entirely different environmental powers, all of which have the ability to make the unprotected antenna inoperative or seriously harmed.

In order to shield the associate antenna from the detrimental effects of the environment, the antennas are covered with an enclosure that protects the antennas from the adverse atmosphere. The shielding of the antenna is also achieved by housing it that, with a sufficiently thin shell that is giant enough, the magnetic force waves can that are been entitled by antennas. The enclosure that are accustomed defend antennas are usually referred to as radomes. A particular radome style is needed to guard its antenna from the encompassing surroundings, whereas simultaneously shouldn't interfere with within the overall performance of the system upon that the antenna is mounted [1].

1.1 Types of Radomes

A Radome is an electronic antenna enclosure. These enclosures area unit manufactured from either rigid self-supporting materials or air inflated versatile materials. Radomes are broadly classified as follows [2]

i. Air borne Radomes
ii. Ship borne Radomes
iii. Ground based Radomes

1.2 Materials:

Material and design are selected to reduce losses at the appropriate frequency while maximizing strength and cost. Airborne radome uses include MMR nose radome and weather radar, sitcom antenna. Antennas for telemetry collection etc.

Typical radomes are made of E-glass, S-glass, Aramid, Quartz and epoxy matrices, cyanate ester, etc., along with various honey comb and foam core materials for sandwich building[3] [4]. Typical surface coatings are polyurethane and advanced anti-static coatings. The combination of various high-tech materials has proved to offer some of the best possible solutions for high-frequency radomes.

1.3 Wall materials

Radoms typically have strong walls or walls like in a sandwich building divided by a heart. The substance that is used for sand, whose walls usually match solid walls. Conventional organic resins such as polyester, epoxy, reinforcing polyimides, such as glass fibers, form wall material for use as radome for aircraft-specific temperatures and are used in solid and sandwich constructions. Inorganic materials such as alumina, piracetam and silica were commonly used as solid wall constructions for greater temperatures.

1.4 Core materials

Reinforced honeycomb plastic components are available in a range of cell wall and reinforcement resins and cell sizes and configurations. Foam materials have evolved beyond the historically widely Plessey is a used rubber nitrogen type, one known as the polyurethane "Hycar" type, now a central substance and a highly stable choice for radomes with enhanced thermal properties, and have shown particular interest in the artificial dielectric region[5].

1.4 Analysis of Radome

Based on the study of the mechanical and electromagnetic properties of composite materials, an appropriate material is selected for the analysis of the Radome Configuration. The technical approach to the problem is a difficult procedure owing to the materials used, the geometry and the working state of the structure, the FEA is used to analyze the radome of old mechanical masses during the flight. ANSYS is used to detect radome displacement and tension under aerodynamic conditions

II. LITERATURE SURVEY

The primary consideration of material selection of radome material is its electrical properties. The radome material should cause less electrical distortion with minimum absorption and transmission losses. In case of radomes for under water applications high mechanical strength is required. After extensive survey of radome material E-Glass reinforcement with epoxy as resin and syntactic foam as core material satisfied both the electrical and mechanical requirements was selected as a radome material.

Author [3] Studied collapse of underwater shells under high external pressure due to buckling and observed that the basic stiffness of the reinforcement fiber plays an important role and suggested high performance carbon epoxy shells with ultra-high module fibers in the thickness portion and even for circumferential stiffening rings would substantially improve buckling strength without any weight penalty.

In recent decades, electromagnetic spectrum has been used for civil and military purposes an increase to improve Electromagnetic sensor output, antenna systems providing lower performance side lobes, multiple frequencies, dual polarization improved tracking and wider bandwidth are of particular importance in this respect.

Airborne antennas are nearly invariably surrounded by radome, the propagation properties of which cancel, or at least slightly weaken, the improved efficiency of the antenna. The electromagnetic properties of Radom are an essential element in the outputs of each unit that radiates or receives. The configuration of the aircraft however is a significant factor in the overall results[6].

Missile radomes share many of the construction challenges of large aircraft radomes, but in this case the choice of materials is more reduced by the higher acceleration and terminal velocities involved and the resultant increase in thermal shock and rain erosion. Error of sight, angular deviations of the bore vision from its position in the absence of a radome, and its rate of adjustment with the viewing angle of the search antenna (i.e., bore signal error sign) would greatly hinder the performance of the directed arm by limiting its available velocity and manoeuvrability.

III. METHODOLOGY

This paper presents the design and analysis of a parabolic radome which is mainly used for aircraft antenna or in sub marine's applications. Depending on the electrical and mechanical requirements, a parabolic radome is selected for the covering of antenna. The literature reviews on the radomes mentioned in the previous section.

The manual calculations are done for finding the stresses, pressure due to wind speed. The depth and height will be given. Later these values shall be compared with the analytical calculation done in ANSYS. Design of parabolic radome is done by using the CREO software, which is mainly used for 3d modeling. The initial sketch is modeled in CREO as shown in the figure 1. The following steps had been performed to create the parabolic radome in CREO.

i. Basic sketch operation is done using dimensions
ii. Revolve tool is used to create the solid model
iii. To create a hole on the flange of the radome insert hole from wizard of the size is required
iv. To create the pattern of the holes on the flange use insert pattern and, in the menu, as give the no of holes required (i.e.,16) to get yet shape
v. To create the counter bore hole on the flange for flanging the radome to the AHU shell. Use hole-extrude and select the size and type of hole and select the location on the flange to insert the hole

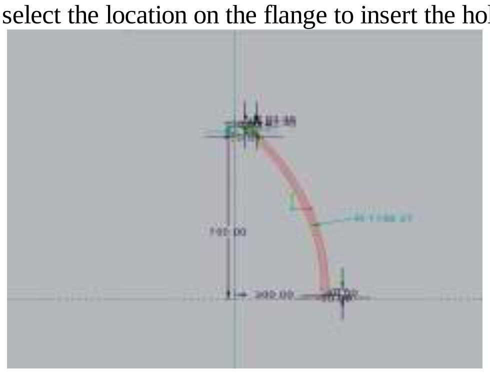

Figure 1: Initial sketching of a radome

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IV. SOFTWARE FOR ANALYSIS

There are numerous commercially software's available for finite element analysis. Finite element Analytic systems benefit from solid simulation and immersive computer graphics applications. Finite element Analytic packages for personal computers are also available at this point, as micro-computer capabilities are increasing, and packages are currently available. Finite Component Analysis (FEA) may be a computational technique for the recognition of engineering and mathematical physics problems. It is useful for problems of sophisticated geometry, loading and material properties anywhere analytical solutions are not available.

The most commonly used software packages for finite element packages are ABAQUS, Adina, Ansys, Cosmos, Gifts, Mare, Nisa, MSc/Nastran, Pafec.

The radome material considered in the analysis is ziconia forcelean. The material characterstics of the radome are listed in the table 1.

Table 1: Material properties of radome

Sl. No	**Property**	**Value**	**Unit**
1.	Density	6.05	g cm^-3
2.	Young's modulus	25000	MPa
3.	Poisson's ratio	0.3	
4.	Bulk modulus	2.0833E+10	Pa
5.	Shear modulus	9.6154+09	Pa
6.	Tensile yield strength	12000	MPa

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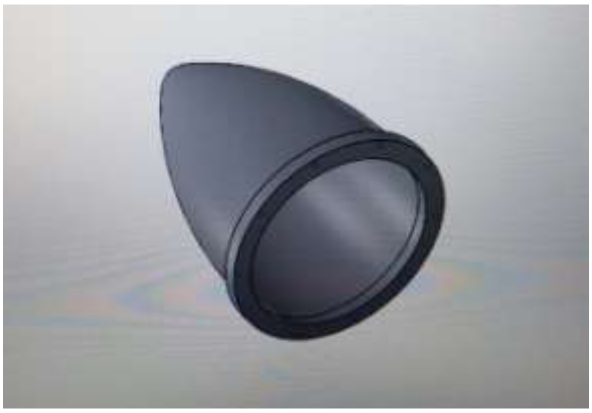

Figure 2: Model of parabolic radome

The components are converted into a FEA model by meshing process in free meshing type. For meshing element size is considered as 0.05mm. Meshing operation is performed till we achieve the finite mesh. The meshing of radome suing ANSYS is shown in figure 3.

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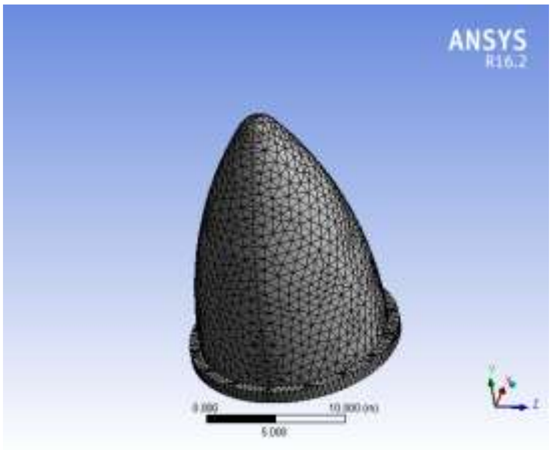

Figure 3: Meshed shape of radome in ANSYS

After design of radome it is subjected to analysis of the strain. Deflections and deformations occurring in radome due to external forces like wind pressure. Analysis of radome is done using ANSYS analysis software. The wind pressure is considered as 6.5 MPA as per the literature review.

1. After analysis, the results are inferred and necessary corrections are made in design of radome for attaining the stable conditions.
2. After the design and analysis. The manufacturing of radome is done.
Manufacturing of Parabolicradome is done by hand layup method, it is heat treated for attaining strength and is sent for finishing. In this application we use zirconia porcelain. Designed and analysis of the radome forms a major part in the manufacturing of radome.

I. RESULTS

Von-Misses stress refers to a failure theory called the von-misses – Hencky certain also known as distortion energy theory is used for ductile failure. In an elastic body the subject to a system of loads in 3D, a complex 3D system in different directions, and the directions and magnitude of stresses change from point to point. Equivalent stress is related to the principal stresses by the equation:

$$\sigma_e=\left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right]^{1/2}$$

[1]

Equivalent stress (also called von Mises stress) is often used in design work because it permits any absolute three-dimensional stress state to be portrayed as one positive stress worth. Equivalent stress is part of equivalent stress failure theory are used to predict yielding to ductile material. The von Mises or equivalent strain ε_e is computed as in eq 2.

$$\varepsilon_e=\frac{1}{1+\nu}\left(\frac{1}{2}\left[(\varepsilon_1-\varepsilon_2)^2+(\varepsilon_2-\varepsilon_3)^2+(\varepsilon_3-\varepsilon_1)^2\right]\right)^{\frac{1}{2}}$$

[2]

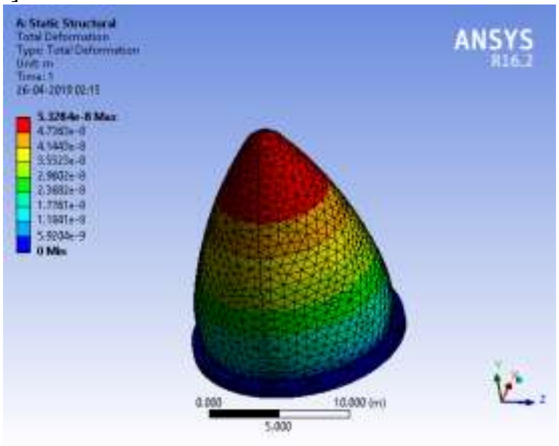

Fig 4: The total deformation of parabolic radome

The equivalent stress of parabolic radome in Ansys is shown in fig 5.

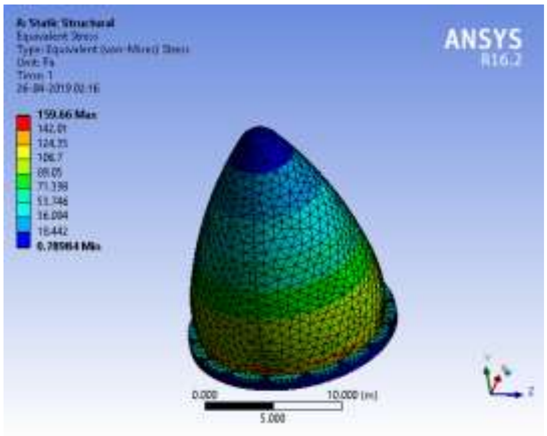

Fig 5: Equivalent stress of parabolic radome

Fig 4 shows the deformation contour of the Parabolic radome. The maximum deformation is observed as 159.66e. This value is less than that of the AHU shell. The contour shown in red color represents the maximum displacement. The displacement is maximum at the radome dome. The contour shown in the blue color is the point of minimum deflection.

It is observed that the values of the Tsai-Wu index, Von-Misses stress and the displacement are well within the permission limits. Hence the radome structure is safe against the hydrostatic pressure of 4.5 Pa

II. CONCLUSION

The radome is modeled using the CREO Software. static analysis is carried out by FEA method using ANSYS and the conclusion are listed below.

i. The maximum deformation obtained for hydrostatic pressure is 5.3284e-8m which is permissible.
ii. The maximum equivalent stress obtained for the radome is 159.66Pa.
iii. The maximum equivalent elastic strain for the radome is 6.3921e-9

FUTURE SCOPE

i. Dynamic analysis can be carried out to check the structures performance under dynamic loads.
ii. To increase the electrical efficiency of the radome without losing its mechanical properties. Hybrid radomes may be assumed to have been built in a futuristic Radom.
iii. Optimization can be done to reduce the size of Antenna head unit.

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