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DESIGN OF AN AIR BORNE RADOME AND FINITE ELEMENT METHOD

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ABSTRACT

Radome is an auxiliary walled in area for Radar/reception apparatus which shields from outer natural burdens. There are a few contemplations in the plan and creation of Radomes. In the current work, Radome with Mounting Bracket is mounted on the wing of the airplane which is moving with 0.8 Mach speed. Stream reproduction examination is completed in SolidWorks programming to separate the weight following up on the outside of the Radome. The weight information acquired from the SolidWorks is applied in the FE model produced inAbaqus V 6.14. The Radome thickness assumes a significant job in the presentation of recieving wire. The Radome thickness is streamlined via doing static and modular investigation.

Key words: Radome *V 6.14*, SolidWorks

1. INTRODUCTION

A Radome is a structural member that protects antenna from environmental loads (wind pressure in case of the present problem) and also acts as an electromagnetic window to the antenna. Radome is one of the important parts of Radar's mechanical construction. The Radome protects the radar against environmental disturbances. There could be some signal attenuation or signal losses introduced by the radome and this level of attenuation should be kept to the minimum. The strength of the radome is one of its important design considerations, but in the process of achieving better strength, the weight should not be increased just like that, as that has other serious consequences on the Radome structure [1]. One more important consideration for a Radome design and selection is cost. The cost incurred in the design and fabrication of a Radome should be much less, when compared to that of the Radar that it is intended to protect. Other design considerations of Radome include the topology, material, mechanical properties and effects of a radome on the transmitted or received signals. Topology or geometric shape plays a vital role in the design of a Radome [2].

Reinforcements such as fiberglass, quartz, graphite, and Kevlar along with materials such as polyester, epoxies, and cyanate ester are used to make advanced composites and special products. Core materials such as honeycomb (fiberglass, aluminium and graphite) and foams (Polyisocyanate and thermoform able cores) are also used. Depending on the application, these parts are oven-cured at temperature up to 400ºF or in autoclaves, which require high-pressure cures at high temperatures. Other materials are also available for special applications. Regardless of the application, we can select the right combination of reinforcement and matrix to meet requirements [3].

SolidWorks is a solid modelling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. SolidWorks is published by Dassault Systèmes.

SolidWorks Corporation was founded in December 1993 by Massachusetts Institute of Technology graduate Jon Hirschtick. Hirschtick used $1 million he had made while a member of the MIT Blackjack Team to set up the company [4]. Initially based in Waltham, Massachusetts, United States, Hirschtick recruited a team of engineers with the goal of building 3D CAD software that was easy-to-use, affordable, and available on the Windows desktop. Operating later from Concord, Massachusetts, SolidWorks released its first product SolidWorks 95, in November 1995. In 1997 Dassault, best known for its CATIA CAD software, acquired SolidWorks for $310 million in stock [5]. Jon Hirschtick stayed on board for the next 14 years in various roles. Under his leadership, SolidWorks grew to a $100 million revenue company [6].

2. FINITE ELEMENT ANALYSIS (FEA)

Abaqus FEA is a software suite for finite element analysis and computer-aided engineering, originally released in 1978. The name and logo of this software are based on the abacus calculation tool. The Abaqus product suite consists of five core software products [7 & 8].

The problem deals with an Air Borne Radome which is mounted on the wing of an aircraft along with a Mounting Bracket. The Radome is constructed using a composite material such as E-glass epoxy, as composites are sensitive to electromagnetic signals. The Mounting Bracket is made up of aluminium.

Initially, the radome model is designed in SolidWorks Software and assembled with the mounting bracket. CFD Analysis is then performed on the radome using wind pressure in Z-Direction as the boundary condition. 0.8 Mach is taken as the wind pressure as it is the average speed with which an aircraft travels. Pressure contours and flow trajectories are observed in SolidWorks software. The pressure variations obtained from SolidWorks software is applied in Abaqus software.

Static and Modal Analysis is carried out in Abaqus Software. Static analysis is the evaluation of material displacement due to stress and also investigates the cause of malfunctioning and failure. It is used in improving the design and avoid failures, to enhance the product performance. Modal Analysis is a structural mechanics which is used to determine mode shapes and natural frequencies of a structure during undamped free vibrations.

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The thickness of the radome is initially assumed to be 2mm as the composite may become insensitive to electromagnetic signals beyond a thickness of 2mm. Static and Modal analysis is carried out on Abaqus. The thickness of the radome is then varied in steps of 0.2mm (1.8, 1.6….1mm) and results are found.

3. STRUCTURAL ANALYSIS INPUTS

Wind speed – 0.8 Mach.
Mounting Bracket geometrical details. Antenna size.
Mounting bracket material.

4. ASSUMPTION

E-glass epoxy material is assumed as lamina. The problem is assumed as plain stress.
Mounting bracket material, aluminium alloy is assumed to be isotropic. Wind flow is incompressible.
E- glass/ Epoxy is assumed to be orthotropic material

5. MATERIAL PROPERTIES

5.1. E-Glass/Epoxy

Table 1 Material Properties of E-Glass/Epoxy

PROPERTY	VALUE
Young's Modulus in X-Direction	25520 MPa
Young's Modulus in Y-Direction	25520 MPa
Shear Modulus in XY Plane	3460 MPa
Shear Modulus in YZ Plane	3460 MPa
Poisson's Ratio	0.229
Failure stress in X-Direction (Tension)	424 N/mm^2
Failure stress in X-Direction (Compression)	-158 N/mm^2
Failure stress in Y-Direction (Tension)	424 N/mm^2
Failure stress in Y-Direction (Compression)	-158 N/mm^2
Plane Shear Stress	88 N/mm^2
Transverse Shear Stress	0
Density	2.1E-009

5.2. Aluminium

Table 2 Material Properties of Al. Alloy 64430-WP

PROPERTY	VALUE
Young's modulus	70000 N/mm^2
Poisson's ratio	0.33
Density	2.7 E-009

Figure 1 Radome- Mounting Bracket Assembly

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6. RESULTS AND DISCUSSIONS

6.1. Static Analysis for Radome Thickness-2mm

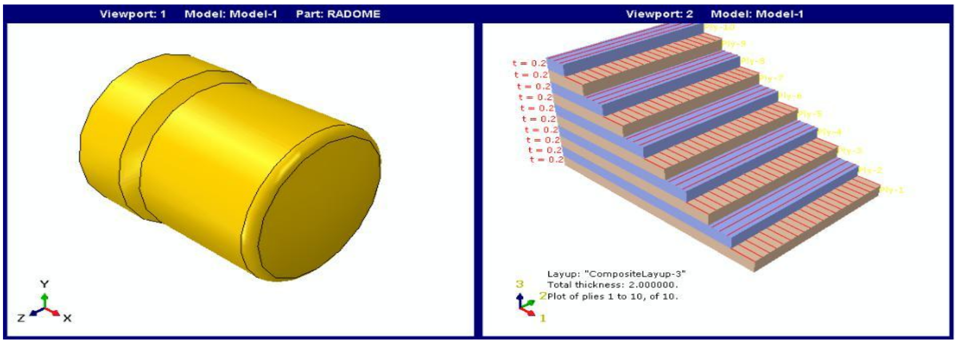

Figure 2 Layup Configuration (2mm)

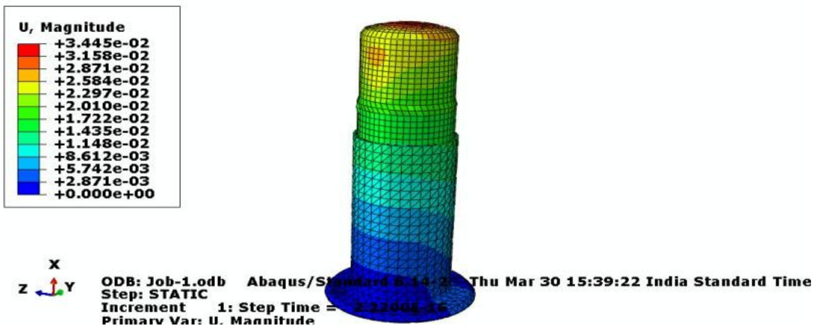

Figure 3 Displacement Contour (2mm)

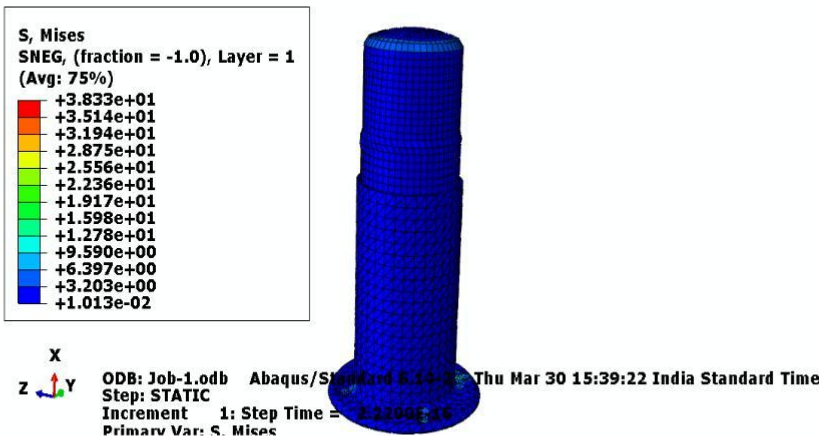

Figure 4 Von Mises Contour (2mm)

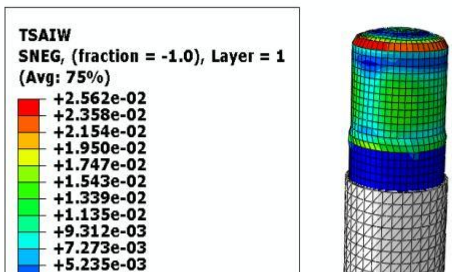

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Figure 5 TSAIW Index (2mm)

Table 3 Static Analysis Results (2mm)

U, Magnitude	+3.445e-02
S, Von mises	+3.833e+01
TSAIW, Tsaiwu	+2.562e-02

6.2. Static Analysis for Radome Thickness-1.8mm

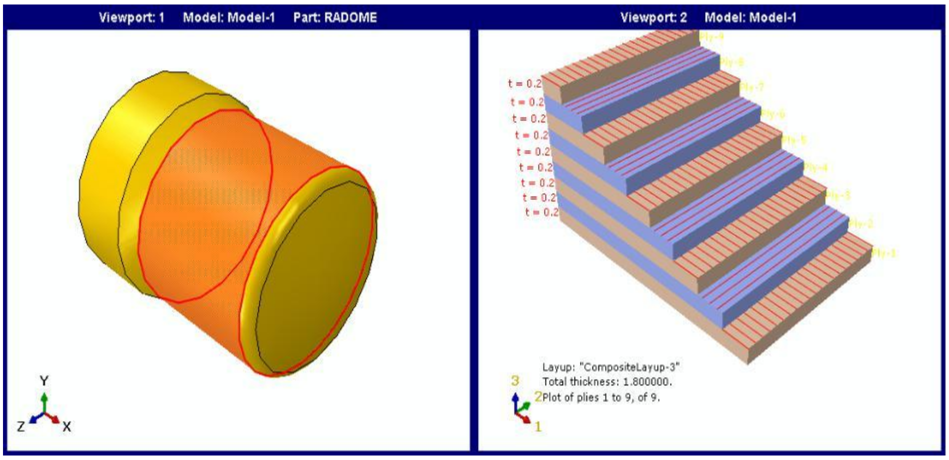

Figure 6 Layup Configuration (1.8mm)

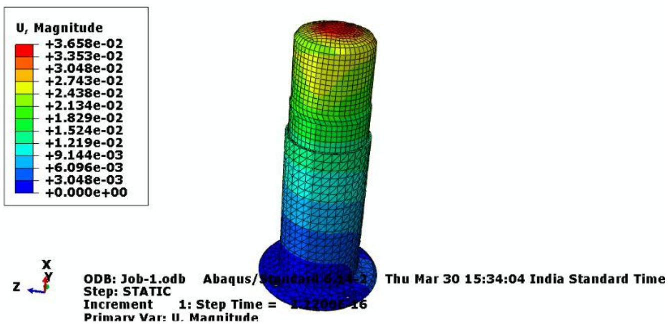

Figure 7 Displacement Contour (1.8mm)

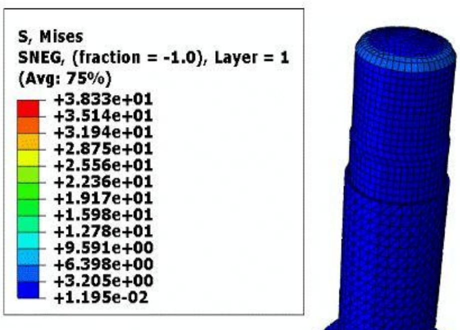

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Figure 8 Von Mises Contour (1.8mm)

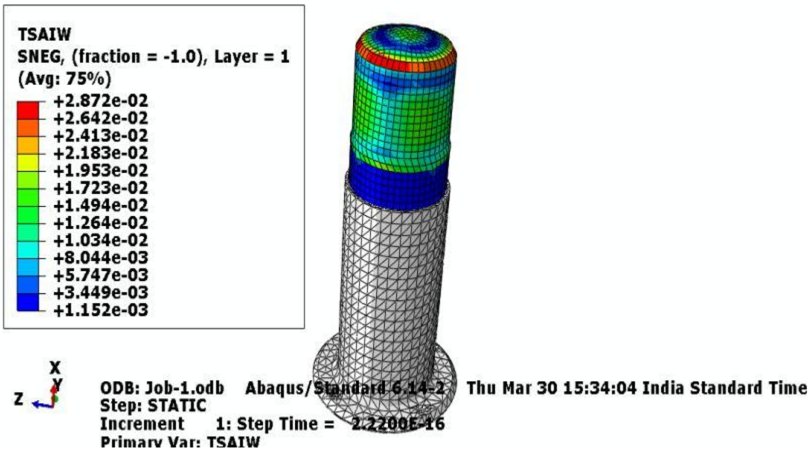

Figure 9 TSAIW Index (1.8mm)

Table 4 Static Analysis Results (1.8mm)

U, Magnitude	+3.658e-02
S, Von Mises	+3.833e+01
TSAIW, Tsaiwu	+2.872e-02

6.3. Static Analysis for Radome Thickness-1.6mm

Table 5 Static Analysis Results (1.6mm)

U, Magnitude	+3.932e-02
S, Von Mises	+3.833e+01
TSAIW, Tsaiwu	+3.258e-02

6.4. Static Analysis for Radome Thickness-1.4mm

Table 6 Static Analysis Results (1.4mm)

U, Magnitude	+4.295e-02
S, Von Mises	+3.833e+01
TSAIW, Tsaiwu	+3.751e-02

6.5. Static Analysis for Radome Thickness-1.2mm

Table 7 Static Analysis Results (1.2mm)

U, Magnitude	+4.295e-02
S, Von Mises	+3.833e+01
TSAIW, Tsaiwu	+3.751e-02

6.6. Static Analysis for Radome Thickness-1mm

Table 8 Static Analysis Results (1mm)

U, Magnitude	+5.602e-02
S, Von Mises Stress	+3.833e+01

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TSAIW, Tsaiwu	+5.400e-02

6.7. Modal Analysis Results for Radome Thickness-1mm

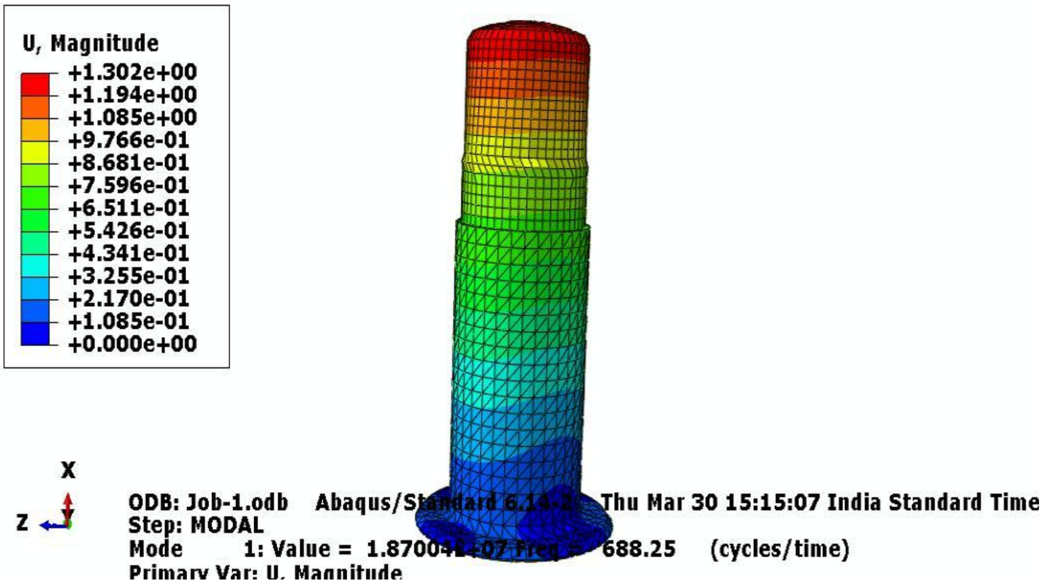

Figure 10 'Mode Shape 1', Frequency-60Hz (1mm)

Table 9 Modal Analysis Results (1mm)

	FREQUENCY (CYCLES/TIME)
Mode 1	688.25
Mode 2	695.85
Mode 3	2541.0
Mode 4	2812.5
Mode 5	2813.4
Mode 6	3216.6

Table 10 Results Comparison Table

DESCRIPTION						
THICKNESS (mm)	2	1.8	1.6	1.4	1.2	1
DISPLACEMENT 'U' (mm)	$+3.445e^{-02}$	$+3.658e^{-02}$	$+3.932e^{-02}$	$+4.295e^{-02}$	$+4.295e^{-02}$	$+5.602e^{-02}$
VON MISES STRESS 'S' (N/mm^2)	$+3.833e^{+01}$	$+3.833e^{+01}$	$+3.833e^{+01}$	$+3.833e^{+01}$	$+3.833e^{+01}$	$+3.833e^{+01}$
TSAI-WU INDEX	$+2.562e^{-02}$	$+2.872e^{-02}$	$+3.258e^{-02}$	$+3.751e^{-02}$	$+3.751e^{-02}$	$+5.400e^{-02}$
NATURAL FREQUENCY 1 (Hz)	631.50	641.74	652.49	663.79	675.69	688.25

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7. CONCLUSION

CFD, Static and Modal Analysis have been carried out for e-glass epoxy radome of antenna for different thicknesses which is varied from 2mm to 1mm. The displacement, Tsai-Wu index and Von Mises stress in static analysis for 1mm thickness radome are +5.602e-02mm, +5.400e-02, +3.833e+01N/mm2 are found well within the acceptable limits. Modal analysis is also carried out for radome of thickness 1mm and first natural frequency is found to be 688.25Hz.

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