Development of a Spherical Radome for a Weather Radar Antenna

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Abstract: According to the technical requirements of a weather radome, an engineering implementation scheme for a weather radome is presented in this paper, centering on its electrical and structural indexes and other operational requirements.

1. Introduction

The function of the radome is to form a closed space around the radar antenna and place the rotating radar antenna in it to protect the radar antenna system from the direct effects of the atmospheric environment. Due to the protection of radome, the antenna system can not be disturbed by wind, sand, rain, snow, hail, which will greatly improve the working environment of the antenna, reduce the design power of the antenna drive device and reduce the actual energy consumption of the antenna rotation, and avoid radar shutdown due to weather and environmental reasons. At the same time, radome can also alleviate the impact of sudden temperature change, solar radiation, humidity, salt fog on the antenna system, so it greatly simplifies and reduces the daily maintenance and repair work of the antenna system, and extends the service life of the radar.

The spherical radome has good electrical performance, good structural rigidity and strong resistance to wind, sand, rain, snow and hail. According to the technical requirements of a certain weather radome, this paper presents an engineering implementation scheme for a certain weather radome based on its electrical and structural indexes and other operational requirements.

1.1 Overall Structure Design of Spherical Radome

According to the technical performance requirements of the product, the structure design mainly considers the electrical performance and structural strength of the two aspects, the whole ball is divided as follows.

The sphere adopts the random block pattern, and the whole sphere is divided into 5 categories: 31 pieces, of which 6 pieces are pentagonal, 10 pieces are hexagonal A, and 5 pieces are hexagonal B (hexagonal A and hexagonal B have the same shape, but different flanges). Hexagon C (1 piece of which is equipped with radome work door structure), quadrilateral has 5 pieces, hexagon C and quadrilateral are respectively connected with the ground foundation. Digital virtual assembly is shown in figure 1.

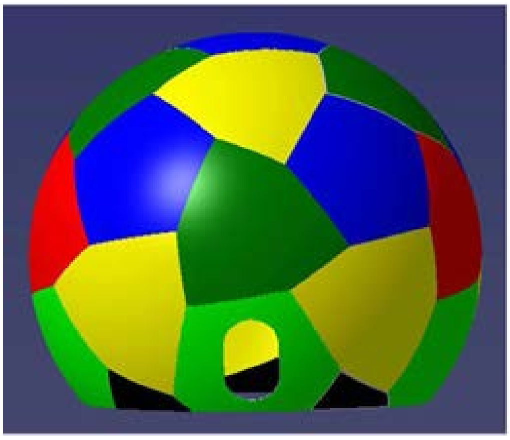

Fig.1 Digital Virtual Assembly Diagram

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1.2 Verification Report on Structural Strength Design of Spherical Radome

The technical requirements of the spherical radome are shown below, which include load, material, and structural requirements.

2. Load, Material and Related Requirements

2.1 Glass Fiber Cloth Specifications

Table 1 Fiber Parameters

The product code	Thickness /mm	Density s/cm		Fracture strength N/25mm		Weight g/m2	Resin	Weaving
SW110C-90a	0.11	22	22	600	600	110	EP epoxy	Four satin 4HS

2.2 Load Index

Wind resistance: when the wind speed is no more than 67 m/s, the enclosure will not be damaged.

2.3 Structure

The antenna radome is a type foam sandwich structure, in which the overlapped part and the bottom flanged part are shown in the figure:

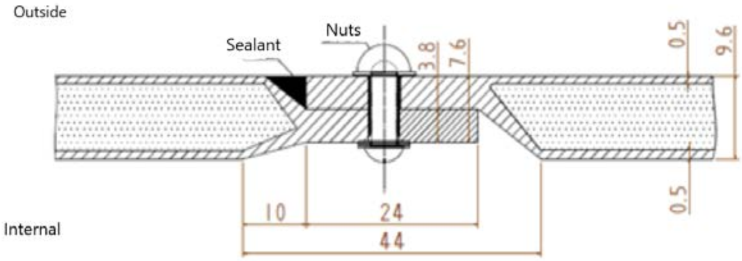


Fig.2 Overlap Structure

3. Simulation of Wind Load and Gravity Conditions of Spherical Radome

Each part of the radome was assembled in accordance with the structure in FIG. 2, and the finite element grid was drawn in accordance with FIG. 3. When the horizontal wind speed was 67m/s, the simulated cloud image of pressure distribution of the sphere was shown in FIG. 4.

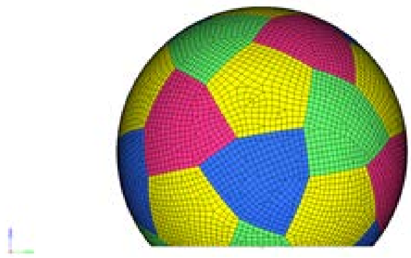


Fig.3 Finite Element Mesh Segmentation

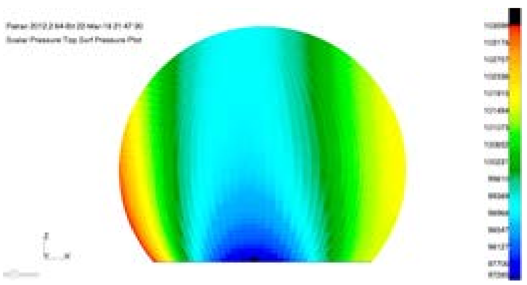
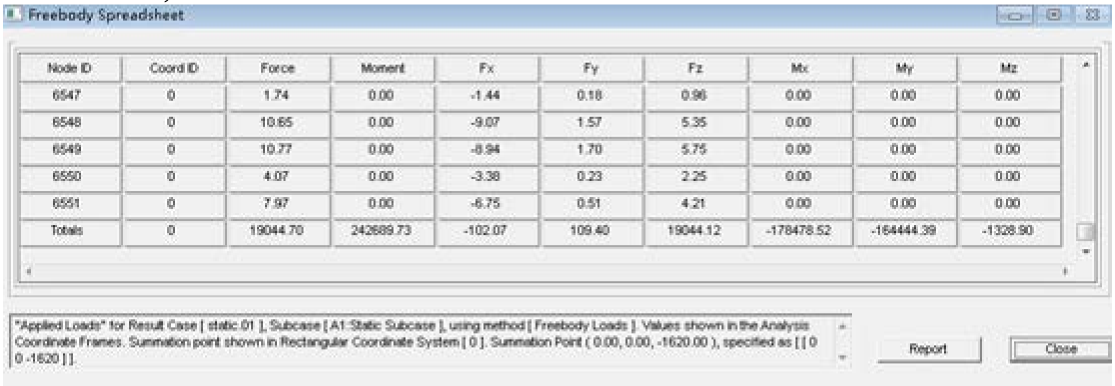


Fig.4 Distribution of Negative Pressure under Wind Load

After simulation, the detailed results of wind load calculation of the radome are shown in FIG. 5.



Freebody Spreadsheet

Node ID	Coord ID	Force	Moment	Fx	Fy	Fz	Mx	My	Mz
6547	0	1.74	0.00	-1.44	0.18	0.96	0.00	0.00	0.00
6548	0	10.65	0.00	-9.07	1.57	5.35	0.00	0.00	0.00
6549	0	10.77	0.00	-8.94	1.70	5.75	0.00	0.00	0.00
6550	0	4.07	0.00	-3.38	0.23	2.25	0.00	0.00	0.00
6551	0	7.97	0.00	-6.75	0.51	4.21	0.00	0.00	0.00
Totals	0	19044.70	242689.73	-102.07	109.40	19044.12	-178478.52	-164444.39	-1328.90

"Applied Loads" for Result Case [static.01], Subcase [A1:Static Subcase], using method [Freebody Loads]. Values shown in the Analysis Coordinate Frames. Summation point shown in Rectangular Coordinate System [0]. Summation Point (0.00, 0.00, -1620.00), specified as [[0 0 -1620]].

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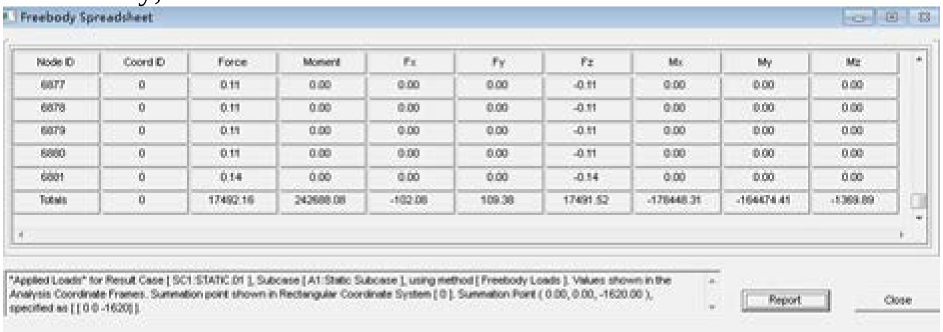
Fig.5 Wind Load Calculation Results

The calculation results of the radome under the double action of wind load and gravity can be obtained in the same way, as shown in FIG. 6.



Freebody Spreadsheet

Node ID	Coord ID	Force	Moment	Fx	Fy	Fz	Mx	My	Mz
6877	0	0.11	0.00	0.00	0.00	-0.11	0.00	0.00	0.00
6878	0	0.11	0.00	0.00	0.00	-0.11	0.00	0.00	0.00
6879	0	0.11	0.00	0.00	0.00	-0.11	0.00	0.00	0.00
6880	0	0.11	0.00	0.00	0.00	-0.11	0.00	0.00	0.00
6881	0	0.14	0.00	0.00	0.00	-0.14	0.00	0.00	0.00
Totals	0	17492.16	242688.08	-102.08	109.38	17491.52	-178448.31	-164474.41	-1369.89

"Applied Loads" for Result Case [SC1:STATIC.01], Subcase [A1:Static Subcase], using method [Freebody Loads]. Values shown in the Analysis Coordinate Frames. Summation point shown in Rectangular Coordinate System [0]. Summation Point (0.00, 0.00, -1620.00), specified as [[0 0 -1620]].

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Fig.6 Calculation Results under Wind Load and Gravity Conditions

Thus, further simulation shows that the cloud image of internal stress simulation of the radome under the dual action of wind load and gravity is shown in FIG. 7.

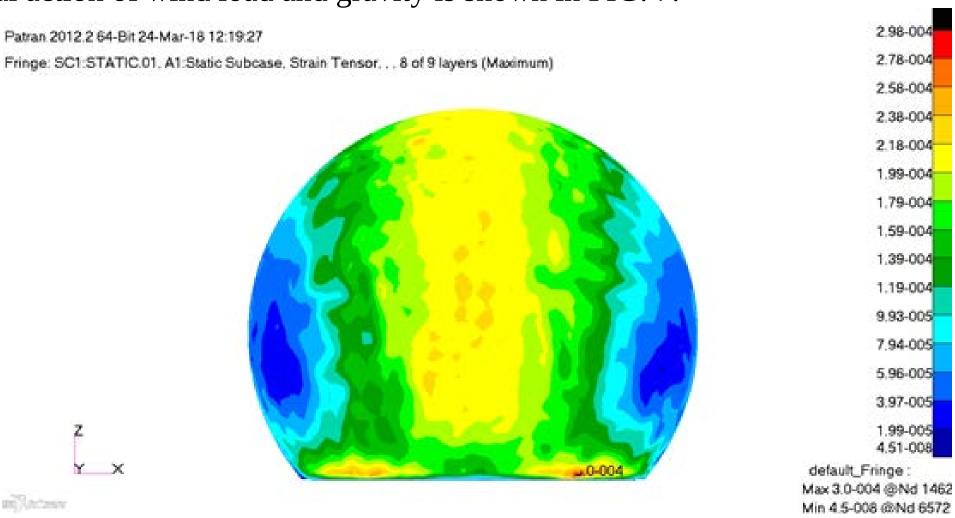

Fig.7 Simulated Cloud Image of Stress inside the Radome under Wind Load and Gravity Conditions

It can be seen from the reference that the fabrication materials of SW110C-90a fiberglass laminar plate used for the rademe have the compressive strength of 440MPa, tensile strength of 536MPa and interlaminar shear strength of 62.1mpa. The maximum simulated stress of the rademe under wind load and gravity is 9.06mpa, which meets the strength requirements.

4. Conclusion

The simulation results show that the structure and strength of the spherical radome meet the technical requirements and can be used normally in the expected operating environment. The radome can fully protect the weather radar, improve the service life of the radar and ensure the stability of the radar function. Similarly, the technology can be fully grafted into the protection of other radars in the same field, as part of the radar body, which will improve the overall level of radar manufacturing on the other hand.

References

[1] Xing Yi, Wang Qiang, Wang Wanyu, Structural Design of 20m Metal Truss Radome [J]. Mechatronics Technology, 2019.04: 5-8

[2] Wei Shengwen. Radar radome heat and humidity resistant technology design [J]. Electrical Machinery Engineering, 2007.23: 1-4

[3] Wang Zi, Weng Lei, Wu Zheng, Lin Zhanxi. Research on Wind Carrier Coefficient of Intercepting Radar Dome [J]. Electrical Machinery Engineering, 2009.06: 11-17