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Numerical Simulation Analysis of Force on 50m³ Small Liquefied Gas Spherical Tank

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ABSTRACT

The strength of liquefied petroleum gas tank is related to production safety. In this paper, aiming at the structural strength of a 50m³ liquefied petroleum gas tank, ANSYS software is used for modeling and strength solving, and the strength of the spherical tank pillar is calculated. The results show that the strength of the liquefied petroleum gas tank meets the design strength standard and is safe.

KEYWORDS

Liquefied Petroleum Gas; Storage Tank; Strength Analysis.

1. INTRODUCTION

Liquefied petroleum gas (LPG) is a high-quality, efficient, clean, low-carbon and clean energy, as well as an important chemical raw material, widely used in chemical raw materials, civil fuel, commercial fuel, industrial fuel, transportation fuel and other fields [1]. With the rapid economic growth, the demand for energy is increasing. As an important energy source, the production and storage of liquefied gas have gradually increased[2], and the reserves have gradually increased, and the storage equipment has gradually developed to a large scale. However, once an accident occurs in the storage of liquefied gas[3], it will cause immeasurable losses to the lives and property of the country and the people. Therefore, domestic and foreign researchers have conducted a lot of research on LPG storage tanks. Xiang Tianlong [4] discussed the design and manufacture of a 3000m³ liquefied gas spherical tank, and introduced the design parameters, design standards, design instructions, technical requirements and material selection. In the manufacturing aspect, it mainly introduces the quality control in the manufacturing process. Shan Hua [5] proposed that the following points should be paid attention to in the design of LPG spherical tank: In the safety setting, the first valve at the root of the spherical tank should be considered as an automatic valve, the lowest liquid level should be involved in the interlocking of pump shutdown, and a separate water injection device should be designed; The surrounding safety facilities should consider the setting of combustible left hair body alarm, human static electricity release column, lightning protection and electric connection. K Sundaravadivu[18] designed a fractional order proportional integral differential controller (FOPID) for the level control of spherical storage tanks and modeled it as a first-order plus pure hysteresis (FOPDT) system. HN Phan et al. [6] confirmed the effectiveness of concave plain bearing system in seismic protection of LNG storage tanks through seismic brittleness analysis[7].

This paper carries out numerical simulation research on the safety of a 50m³ LPG storage tank, and ensures the safety of the tank through model establishment, grid division and force analysis

2. MODEL AND MESH DIVISION

The main parameters of the spherical tank are shown in Table 1.

Table 1. Design and operation parameters of 50m^3 spherical tank

Original condition	Data	Original condition	Data
Working pressure	1.6MPa	Design temperature	20°C
Inside diameter of spherical tank	4.6m	Filling coefficient	0.9
Store material	Liquefied petroleum gas	Welded joint coefficient	1.0
Material density	ρ_1=480kg / m^3	Intensity of earthquake fortification	8°
Number of pillars	4 roots	Tie rod selection	ϕ 36 Round steel
Material density of spherical shell	ρ_2 = 7850kg / m(Q345R)	Prop selection	ϕ 219×10 Steel tube
Density of water	ρ_3=1000kg / m^3	Basic wind pressure	q_0 = 350N / m^2
Basic snow pressure value	q = 300N / m^2	Snow coefficient of the sphere	Cs=O.4
Spherical tank construction site: Class II field land, near earthquake, Class B area			

Due to the symmetry of the overall structure of the spherical tank and the pillar, the 1/3 overall model of the connection between the spherical tank and the pillar was constructed by three-dimensional modeling software solidworks.

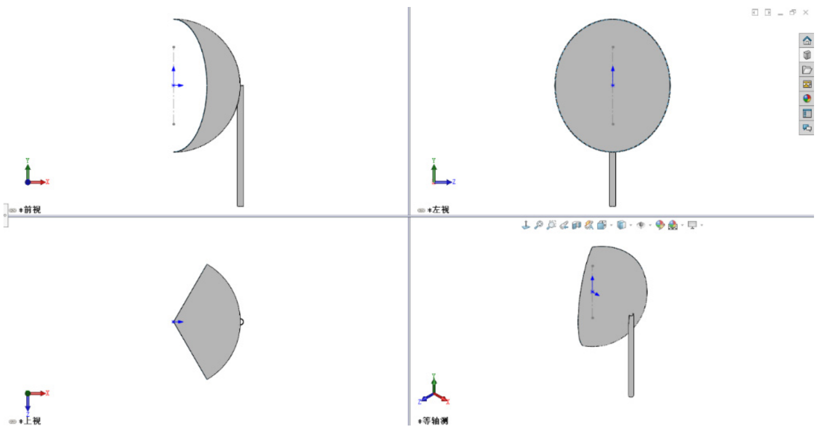

Fig 1. Schematic diagram of spherical can model

Import the model into workbench and divide the grid, as shown in Figure 2:

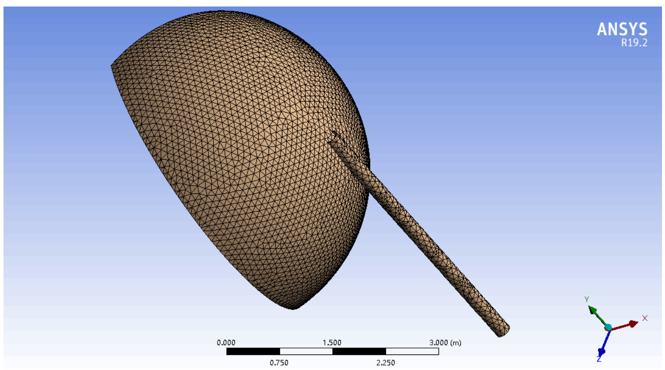

Fig 2. Refined mesh (mesh spacing 0.1mm)

3. CONCLUSION AND ANALYSIS

3.1. Gravity Load Stress Analysis

After dividing the grid, ANSYS software is used to simulate and calculate the distribution of stress and deformation of the spherical tank and pillar under the dead weight, normal operation and hydraulic test conditions, so as to preliminarily analyze the rationality of the optimization design.

Gravity load is a static load of a vacuum metal tank under static conditions have the effect of vertical downward gravity load, load under general conditions take g=9.81m/m^2. Under the action of gravity load, the total displacement diagram of the spherical tank and pillar after numerical calculation and analysis is shown in Figure 3, and the overall equivalent stress cloud diagram of the spherical tank and pillar is shown in Figure 4.

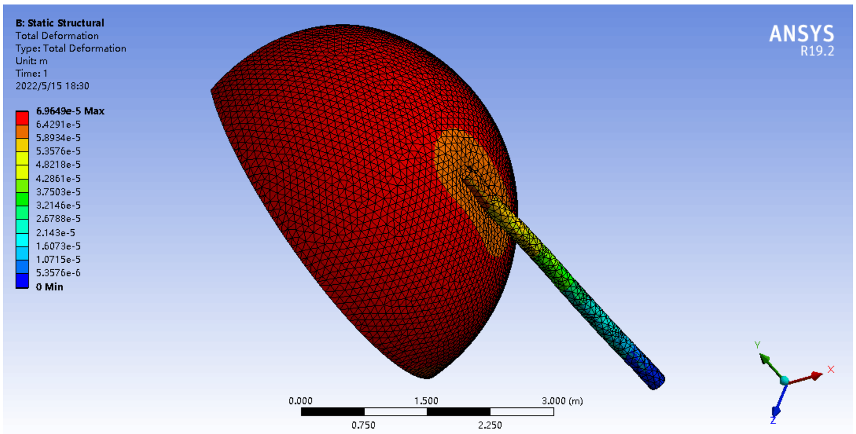

Fig 3. Total displacement diagram under gravity.

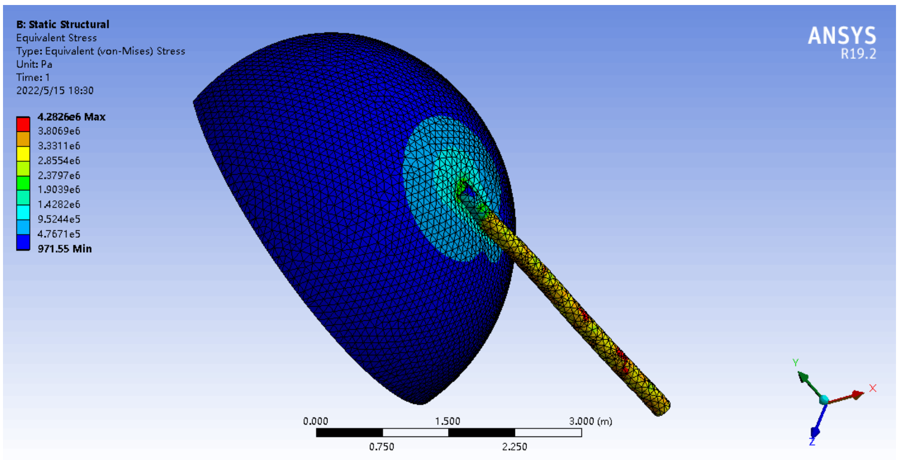

Fig 4. Cloud map of stress distribution under gravity

After numerical calculation and analysis by adding gravity load, as shown in Figure 3, the maximum displacement of the spherical tank and pillar under the condition of self-weight is 0.0695mm, in which the north and south plate displacement is the largest. As shown in Figure 4, the maximum compressive stress of the spherical tank and pillar is 4.28MPa, among which the pillar is the largest compressive stress and is the main bearing body of the whole vacuum spherical tank.

3.2. Stress Analysis under Operating Conditions

In the operating state, the design pressure is 1.6MPa, the material density is 480kg/m³, and the filling coefficient is 0.9. After numerical calculation and analysis, the total displacement of the spherical tank and pillar is shown in Figure 5. The overall equivalent stress cloud diagram of the spherical tank and pillar is shown in Figure 6.

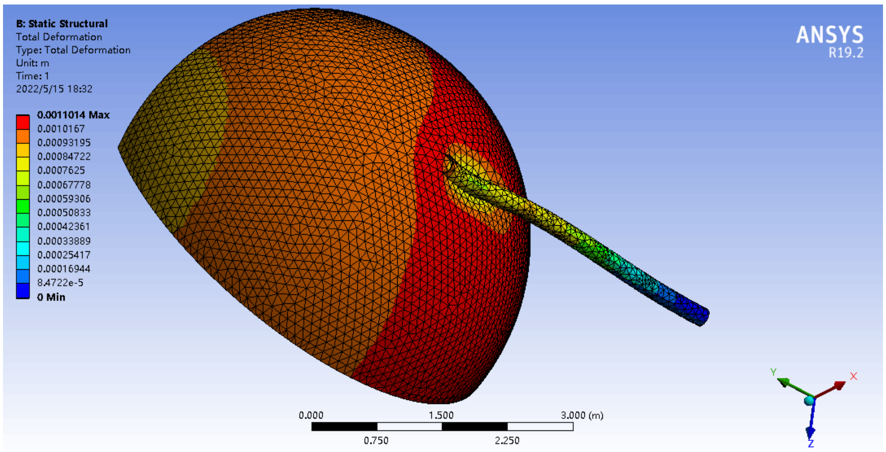

Fig 5. Total displacement diagram in the operating state

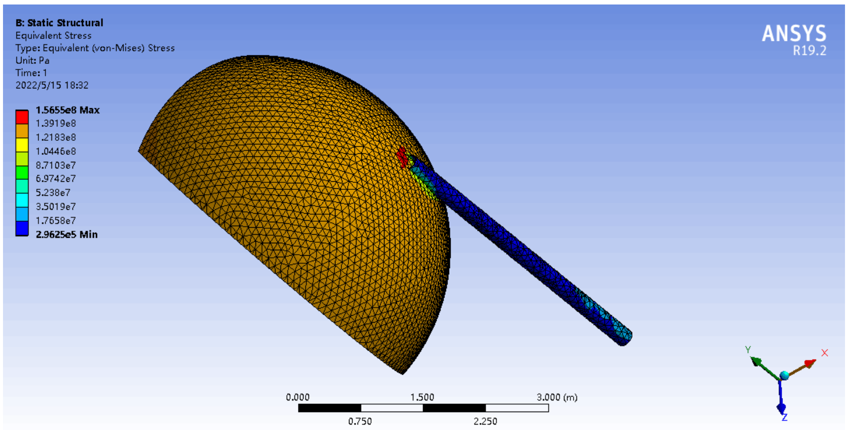

Fig 6. Cloud map of stress distribution in the operating state

As shown in Fig. 5, it can be seen from the overall displacement diagram under operation condition that the largest deformation area is the sphere shell and the connection area between the sphere shell and the pillar, the maximum displacement is 1.1mm, and the smallest deformation area appears on the foundation surface and the interface end face of the pillar. As shown in Fig 6, it can be seen from the overall stress cloud map that the largest stress area is the connection area between the spherical shell and the pillar, and the maximum stress value is 156.55MPa.

4. CONCLUSION

In order to ensure the safety of the spherical tank design, the finite element analysis of the model using ANSYS analysis software in this paper shows that the number of 50m³ spherical tank pillars designed from 4 to 3 can meet the requirements of structural strength, thus providing a new idea for the production cost saving of LPG spherical tanks.

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