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Verification Design of Stress Strength of Storage Tank Support Based on Finite Element Method

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Abstract: Based on ANSYS software, stress analysis was conducted on the bottom of the storage tank, and the container stress was checked using stress classification methods. The comparison was made with the situation without supports, which can provide some reference for practical engineering applications.

Keywords: Numerical simulation, Stress analysis, Vertical support.

1. Introduction

Container supports refer to structural components used to support and secure containers or equipment, typically located at the bottom or side of the container. The container support can provide stable support and load-bearing capacity, enabling the container to safely carry its internal substances or media. They can disperse the weight of the container and transfer it to the foundation or supporting structure, ensuring the stability and structural integrity of the container. Containers may be affected by vibrations and vibrations during operation, and container supports can reduce the transmission of these vibrations and vibrations, thereby reducing adverse effects on the container and surrounding equipment. Some containers need to work in high-temperature environments, and the container support can serve as a thermal isolation layer to reduce heat conduction and loss. Therefore, by selecting appropriate materials and designs, container supports can help reduce energy consumption and improve thermal efficiency. And the container support needs to have corrosion and wear resistance characteristics, especially in environments that come into contact with corrosive media or substances. This helps to extend the service life of containers and support structures, and reduces maintenance and replacement costs.

The research on container supports is of great significance. By studying the properties and characteristics of new materials, it is possible to develop container supports that are more resistant to corrosion, wear, strength, and rigidity. This helps to improve the reliability and service life of the container and meet specific engineering requirements. Studying the structural design of container supports can optimize their load-bearing capacity, shock absorption effect, and thermal conductivity. Through reasonable structural design, the risk of stress concentration and fatigue failure can be reduced, and the reliability and safety of the support can be improved.

Zhang Jie[1] takes a 15m3 low-temperature vertical storage tank as an example, and uses the finite element analysis software ANSYS to analyze and verify the local stress of the head of a low-temperature vertical container that directly selects the standard supporting support in JB/T4732-2005 [2]. The verification results show that the local stress of the head cannot meet the requirements. To address this issue, a structural improvement type support was proposed and compared with a parameter improvement type support that simply increases the design size. Through the comparison of finite element analysis results, it was verified that the effect of structural improved bearings on equipment stress improvement and structural optimization is better than that of parameter improved bearings. In addition, structurally improved bearings can significantly save costs. The support has performed well in practical use. Su[3] combined the requirements of NB/T 47065.4-2018[4] for support pads with the finite element analysis software ANSYS to analyze and verify the stress at the tank head. The verification results show that there are still areas for improvement in the local stress concentration area of the head. To solve this problem, a combination of response surface method and multi-objective genetic algorithm is used to optimize the structural dimensions of the support pad. By comparing the results, it was found that the optimized design of the support pad can significantly reduce costs.

In order to study the effect of support on the stress distribution of the bottom head of a storage tank in a certain project, Solidworks software was used for solid modeling. The static structural module in ANSYS was used for grid division and stress calculation, and the simulation results were compared with the stress distribution of the bottom head of a storage tank without support.

2. Geometric Modeling and Boundary Conditions

2.1. Geometric and mesh model

The structure diagram of the storage tank is shown in Figure 1, and the three-dimensional Geometric modeling in Solidworks is shown in Figure 2:

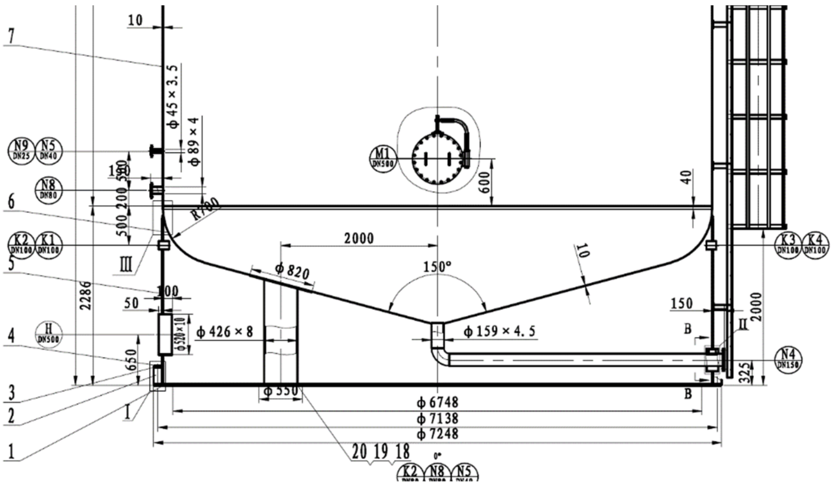

Figure 1. Structural schematic diagram of storage tank

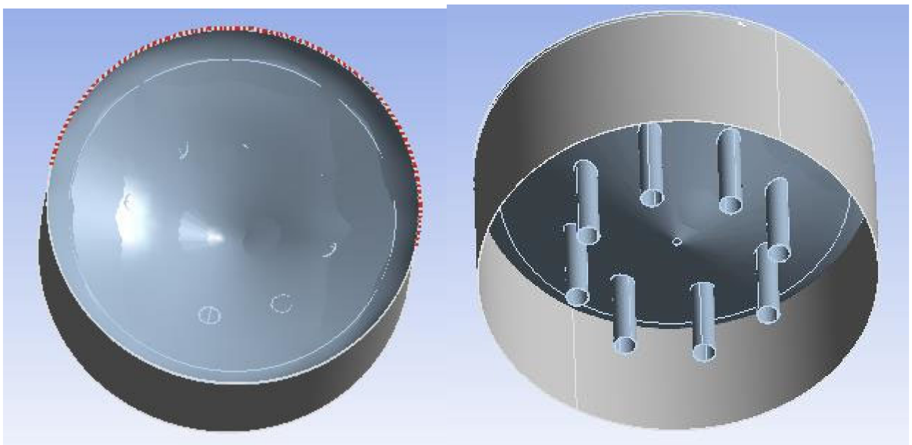

Figure 2. Three dimensional Geometric modeling of storage tank

Control the grid size to 0.1m and divide it as shown in Figure 3:

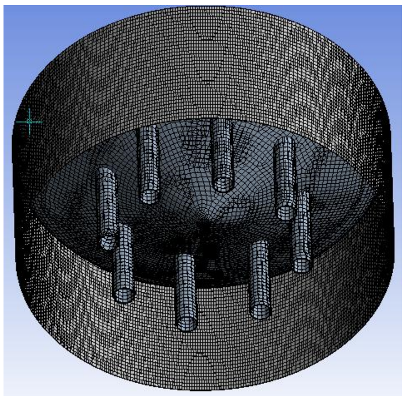

Figure 3. Grid diagram of storage tank

The material of the storage tank is set to stainless steel, and the physical parameters of the material are shown in Table 1:

Table 1. The physical parameters of the material

Physical parameters	Numerical value
Young's Modulus	2e+11 Pa
Density	7930 kg/m³
Poisson's Ratio	0.3
Bulk Modulus	7.6923e+10 Pa
Shear Modulus	7.6923e+10 Pa

2.2. Boundary conditons

Set the bottom and side of the support skirt as Fix Support to meet the axial and radial force limitations of the storage tank, so that a pressure of about 0.1Mpa is applied to the head of the container, without considering thermal effects. The calculation time step is 0.1s, and the total calculation is one hundred steps.

3. Analysis of Calculation Results

The stress distribution at the bottom of the storage tank without supports is shown in Figure 4 (a). After adding eight supports, the stress distribution at the bottom of the storage tank is shown in Figure 4 (b). From the calculated Van Mise stress diagram, it can be intuitively seen that the stress at the bottom of the storage tank without supports occurs in the variable diameter section of the head, about 3.6X108Pa. After adding supports, the stress at the same position becomes 3.5X107Pa. From this, it can be seen that the support can significantly improve the stress distribution of the variable diameter section.

According to JB/T4732, one overall film stress SI and one local film stress SII should meet the design stress intensity values S_m:

$$S_I \leq S_m \tag{1}$$

$$S_{II} \leq 1.5S_m \tag{2}$$

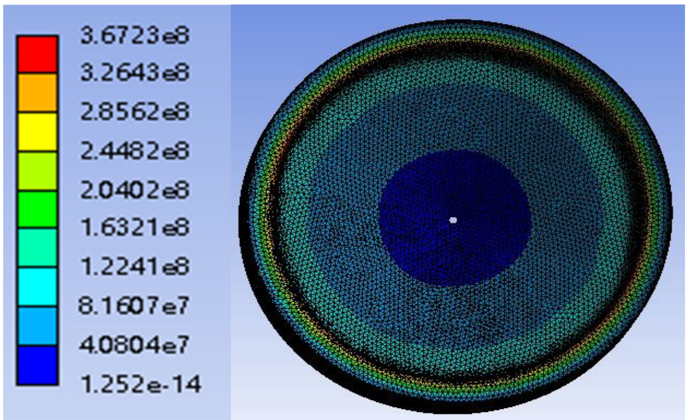

Figure 4(a). The stress distribution without supports

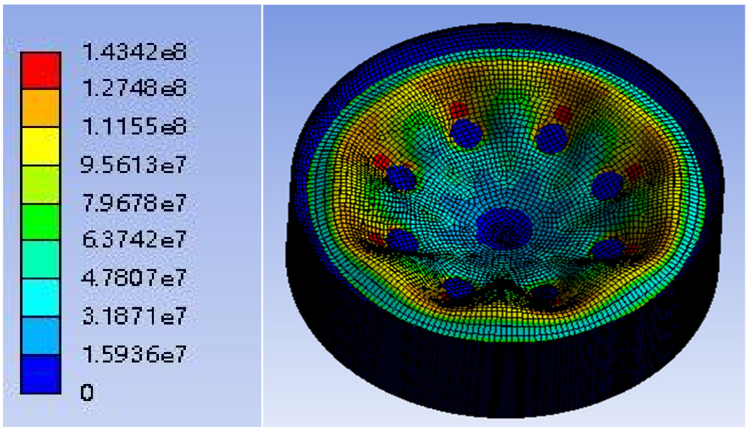

Figure 4(b). The stress distribution with supports

Finding that SI is equal to $9.56X10^8$Pa, SII is equal to $2.06X10^9$Pa. All meet the requirment of expression (1)and(2).

4. Summary

(1) The support effectively improves the stress distribution at the bottom of the storage tank, especially in the variable diameter section of the head.

(2) Verifying through stress classification method, one overall film stress SI and one local film stress SII meet the requirment of stress check.

References

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