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Optimization Design of Gasholder of Air Compressor based on ANSYS Workbench

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Abstract: In this paper, we use ANSYS Workbench to optimize the air compressor gasholder structure, under the premise of satisfying strength and stiffness, based on the principle of economy, reduce the stress concentration of the head, reduce the thickness of the head and cylinder, and provide a reference for the structural design of gasholder.
Keywords: gasholder; structural optimization design; finite element

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1. INTRODUCTION

The optimal design mathematical model can be expressed as [1]

Objective function:

$$f(X) = f(x_1, x_2, \ldots, x_n)$$

Constraint condition:

$$g_i(X) = g_i(x_1, x_2, \ldots, x_n) \le 0 (i = 1,2, \ldots, n)$$

$$\mathrm{h}_i(X) = h_i(x_1, x_2, \ldots, x_n) \le 0 (i = 1,2, \ldots, p)$$

ANSYS has powerful optimization design function. It can not only make structural size optimization, but also do topology optimization. [2].The horizontal gasholder of air compressor used to store compressed air, which can meet the demand of sudden increase of gas consumption for gas equipment, buffer the fluctuation of air pressure, ensure air continuous and stable output in the pipeline, reduce the frequent starting times of the air compressor, protect the equipment, and improve the production efficiency of the equipment at the same time. The air compressor horizontal air storage tank three-dimensional model is shown in Figure 1. The superior surface has inlets and outlets. It can be selected to use according to the need, and the plug can be blocked with the mouth. The working pressure of the gas tank shall not be higher than the maximum working pressure. There is a drainage outlet at bottom, which can be used to discharge water to prevent corrosion inside the gasholder. The gasholder body is mainly composed of heads and a cylinder, and the gasholder body has a section that is elliptical.

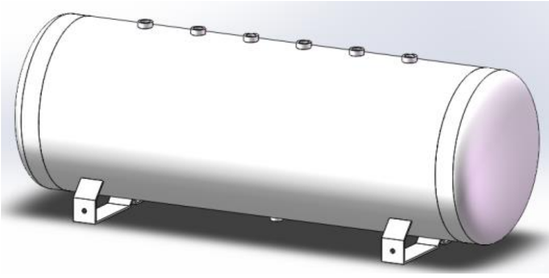

Fig. 1 air compressor horizontal air storage tank three-dimensional model

Before finite element analysis, simplified model, remove the inlet and outlet and drainage holes. This is because the mesh is densely divided at the hole and other structures, and the small hole has little influence on the structural strength. The simplified model is shown in Figure 2

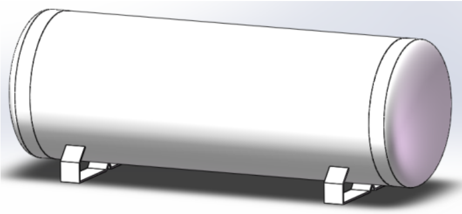

Fig. 2 simplified model

2. STRESS ANALYSIS OF GASHOLDER OF AIR COMPRESSOR UNDER WORKING CONDITION

The air compressor gasholder material is carbon steel. Because the gasholder is regular shape, simple structure, we use the method of automatically divide grid. Due to the bottom bearing surface is relatively large, set the grid size, re-mesh, and the final mesh as shown in Fig. 3, there are 85273 Nodes, 42392 Elements.

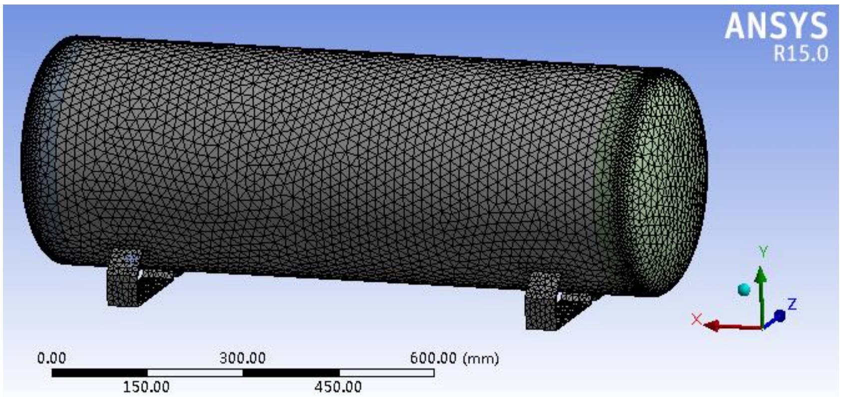

Fig. 3 grid partition

The static analysis of gasholder is carried out by using ANSYS Workbench. According to the loading and constraint conditions, vertical downward gravity is placed, and the position of fixed constraint is on the bottom of the support. The pressure exerted on the inner surface of the gasholder is 1 MPa. The gasholder head stress distribution as shown in Fig. 4, the cylinder equivalent stress distribution as shown in Figure 5. The maximum stress of head is 149.08MPa, the maximum stress position near the cylinder. Because of the structure size quickly changes, we can change the size of the structure to reduce the stress concentration. The cylinder maximum stress is smaller than head, the maximum stress is 50.005MPa, obviously, optimization design of the head short axle length parameter can reduce the stress concentration, optimization design of head thickness and cylinder thickness can reduce quality.

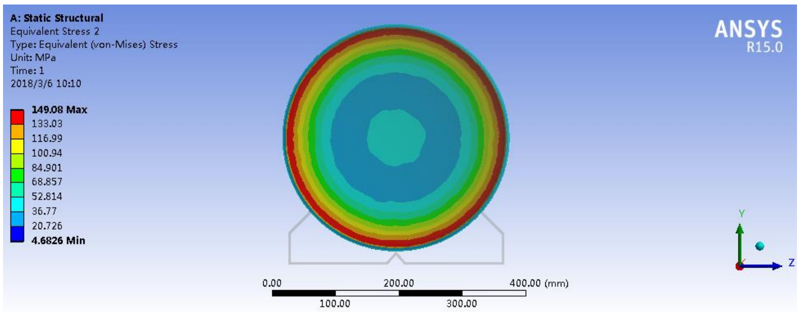

Fig. 4 equivalent stress nephogram of head

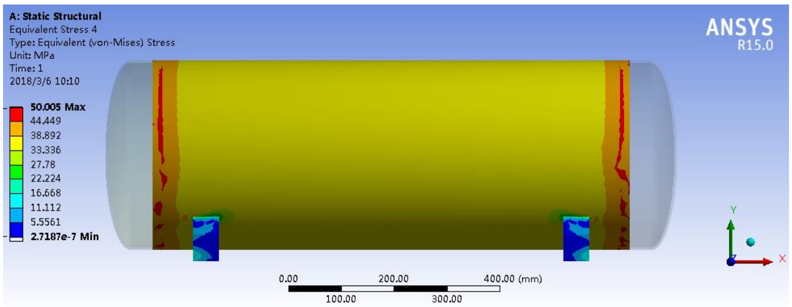

Fig. 5 equivalent stress nephogram of cylinder

3. OPTIMIZATION DESIGN

Parameterize the short half shaft length, the thickness of the cylinder and the thickness of the head. In Solidworks, the prefix DS_ is needed before the name of the parameter, and the modeling feature in SOLIDWORKD should be named in English. The thickness of the cylinder is DS_h1, the thickness of the head is DS_h2, and the short half axis of the head is DS_L. The three parameters are optimized one by one separately, and the structure size is optimized by the response surface optimization analysis module.

Reference to the preceding stress analysis results, set DS_h1 range from 2mm to 4mm, and the relationship between the equivalent stress of the cylinder and the cylinder thickness is optimized as shown in Figure 6. The head thickness is smaller, the head maximum stress is larger. When the thickness of the head is 3mm, the equivalent stress of the cylinder is $6.3605\times10^{7}\,Pa$ ($63.605\,MPa$)

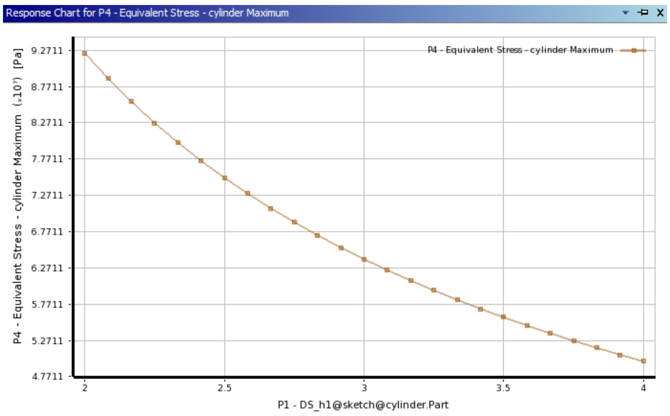

Fig. 6 curve of relationship between equivalent stress and thickness of the cylinder

Set DS_L range from 45mm to 60mm, optimization result is shown in Figure 7. The half shaft length of the head is longer, the maximum stress of the head is smaller. When the head half length of the head is 60mm, the equivalent stress of the head is less than $1 \times 10^8 Pa(100MPa)$. The thickness of the head can then be optimized based on this.

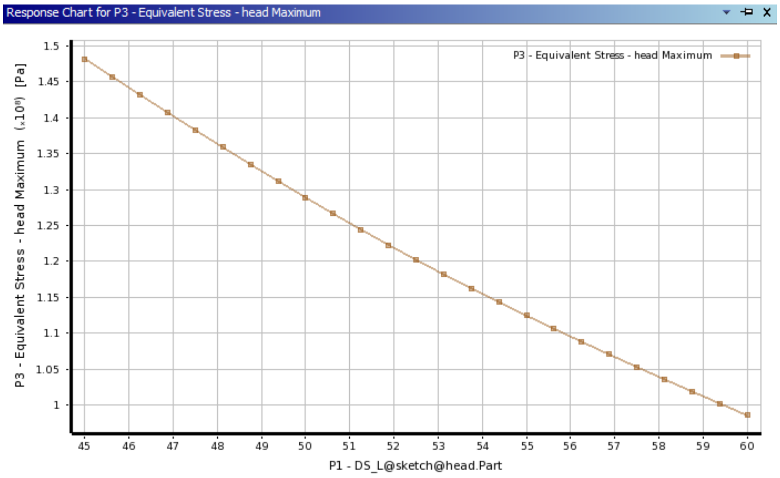

Fig. 7 curve of relationship between equivalent stress and short half shaft length of the head

At the head of the equivalent stress and the short axle length optimization design, set DS_L range from 45mm to 60mm, optimization results are shown in Figure 7. The wall thickness is smaller, the head of the maximum stress is larger. Observe Fig. 7, when the thickness of the head is 4mm, the cylinder equivalent stress is about $1.30 \times 10^8 Pa(130MPa)$

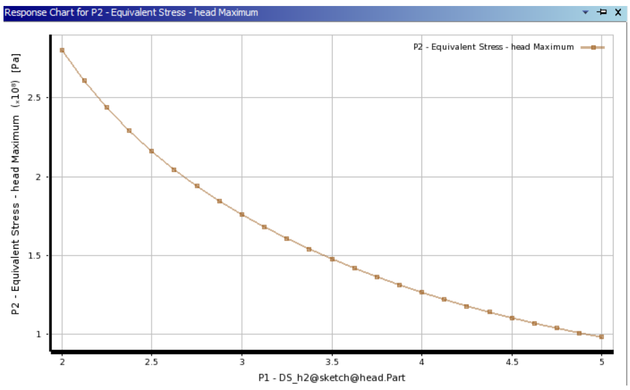

Figure 8 curve of relationship between equivalent stress and short half shaft length of the head

Although strength redundant, we have not analyzed other requirements such as stiffness. Therefore, the wall thickness should not be too thin, and the optimized wall thickness should be rounded. According to the optimized design results above, we select the short half axis length of the final head is 60mm, cylinder thickness is 3mm, and cylinder thickness is 4mm , build optimized model and analysis to check strength.

4. STRENGTH CHECKING AFTER OPTIMIZATION

Check gasholder strength is carried out by using ANSYS Workbench for the optimized model of gasholder, and the working condition is the same as that in the front. The stress nephogram diagram of the cylinder is shown in Figure 9. The stress nephogram of head is shown in Figure 10.It can be seen that the stress distribution law is the same as that before optimization. After optimization, the maximum stress of the head is 125.69MPa, and the maximum stress of the cylinder is 64.786MPa.

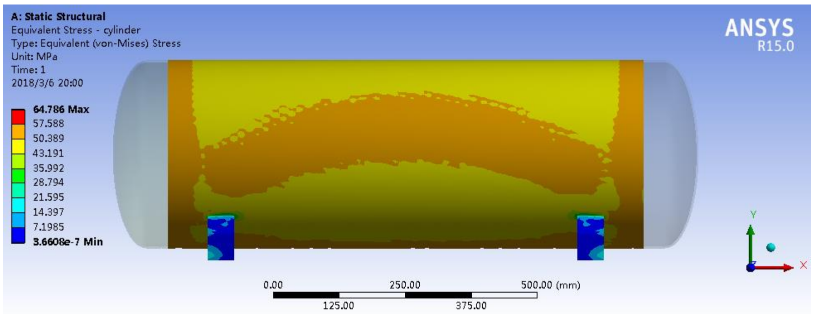

Fig.9 stress nephogram of cylinder

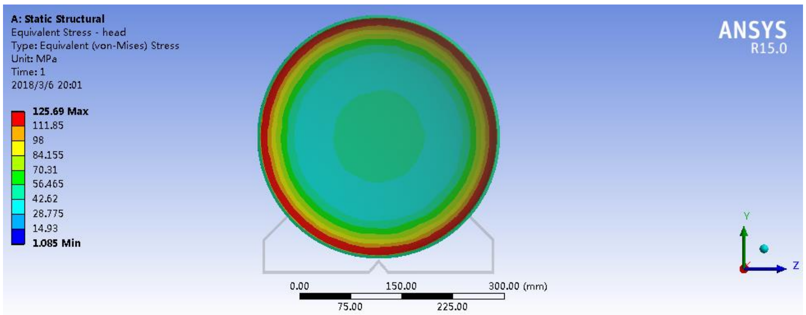

Fig. 10 stress nephogram of head

5. CONCLUSION

We use Workbench optimization analysis gasholder module, We modify the size of head short axle length increase from 45mm to 60mm, the stress concentration is reduced, the structure is more reasonable. Although strength redundant, we have not analyzed other requirements such as stiffness, the head thickness is decreased from 5mm to 4mm, and the cylinder thickness decreased from 4mm to 3mm, the quality of the gas tank is reduced. But simulation can only provide reference, which need experiment verification.

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