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SEISMIC PERFORMANCE ANALYSIS OF BLAST FURNACE SHELL STRUCTURE

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In this paper, the finite element software ANSYS is used to establish a three-dimensional space model of the blast furnace shell, and the static analysis of the space steel structure system of the blast furnace is carried out. The seismic response of the outer shell system of the blast furnace is analyzed by response spectrum method and linear time history analysis method, so as to explore the seismic response of the blast furnace shell.

Keywords: blast furnace, shell, seismic performance, finite element, response spectrum method

INTRODUCTION

China is adjacent to the seismic belt of the Pacific Ocean and the Seismic belt of the Indian Ocean, and is one of the earthquake-prone countries. As an important large-scale industrial equipment, the blast furnace is related to greater economic benefits and social security. Therefore, enough attention should be paid to the seismic performance of the blast furnace in engineering design practice [1].

At present, the steel structure design of blast furnace in China mainly relies on traditional experience and existing specifications, assisted by numerical simulation. With the enrichment and upgrading of boiler forms and the improvement and improvement of the use requirements, the traditional design method is sometimes difficult to meet the design requirements of practical engineering, so it is necessary to use finite element software to evaluate and analyze the boiler safety, and further guide the engineering practice [2].

In this paper, a large blast furnace shell structure is taken as the research object, and the general finite element software ANSYS is used for modeling [3]. Response spectrum analysis and seismic time history analysis are carried out to evaluate the seismic performance and seismic safety of the blast furnace shell structure.

PROJECT OVERVIEW

In this paper, the blast furnace shell of an iron-making plant at an iron and steel base is selected as the research object, the volume of which is 5 300 m^3. The total height of the furnace shell is 50,9 m, which is axisymmetric and divided into 20 plates with different diameters from top to bottom, which are welded by steel plates with thickness of 50mm~85mm in turn. 20 uniform circular vents are arranged at +16,200m elevation in the hearth area, and 4 circular outlet holes are arranged at the top sealing cover. The 3d model of furnace shell is shown in Figure 1.

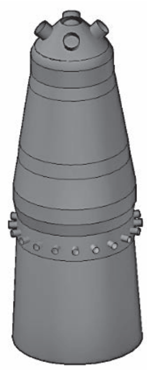

Figure 1 Schematic diagram of a blast furnace shell

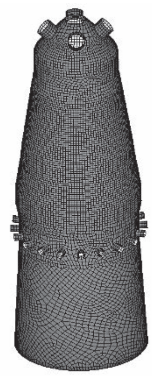

Figure 2 Schematic diagram of finite element model of a blast furnace shell structure

NUMERICAL MODELING

According to the structural engineering information, the finite element model is established by using ANSYS software. Steel Q345 was selected, with elastic modulus of 2,06×105 MPa, Poisson's ratio of 0,3 and density of 7 850 kg/m^3. An ideal elastoplastic model was adopted to consider the nonlinear properties of the material. The yield strength and ultimate strength were 345 MPa and 450 MPa respectively. The finite element model is simulated by planar shell element (Shell 181 element). The mesh is divided into quadrilateral elements supplemented by triangular elements, and the mesh size is 0,3m. Each node has six degrees of freedom (three transla-

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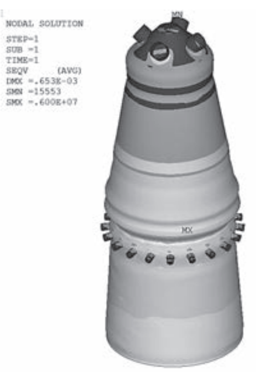
tional degrees and three rotational degrees), and the element has a quadratic function in each direction of the plane, which takes into account the effects of stress hardening, plasticity, large strain and large deformation[4]. As the research object of this paper is the seismic performance of the whole structure, the common node technology is used to simulate steel welding. After the surfaces are bonded by Aglue command, the grid is divided. The finite element model of blast furnace shell structure is shown in Figure 2.

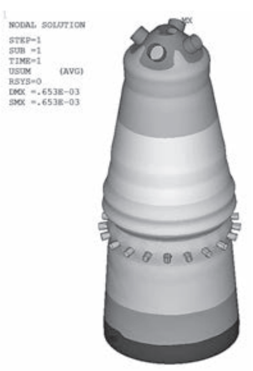
The hot air pressure is 0,525 Mpa, the top pressure is 0,3 Mpa, and the total weight of the additional structure (including the additional mass of the equipment and the feeding mass) is 284,6 tons, which is transmitted to the furnace shell through the supporting column of the blast furnace top charging tank.

STATIC ANALYSIS

Considering the dead weight effect of blast furnace, burden load, overall temperature difference of 10 degrees Celsius between the inside and outside of the shell [5], inner liner expansion force, gas and slag iron pressure, the static analysis of blast furnace shell structure is carried out, and its equivalent stress and displacement are shown in Figure 3.



(a) Equivalent stress (maximum 6,0 MPa)



(b) Structural displacement (Max. 0,65 mm, vertical)

Figure 3 Static analysis result

According to the results of static analysis, the maximum stress of furnace shell is 6 MPa, and the combined displacement is less than 1mm, so the structure is elastic and safe.

MODAL ANALYSIS

In order to obtain the dynamic characteristic parameters of the structure, the modal analysis is carried out. Extract the first six periods and modes, as is shown in Figure 4.

From the above analysis results, the structural vibration type is mainly based on the plate drum curvature, until the overall mode appears in the fifth order vibration type.

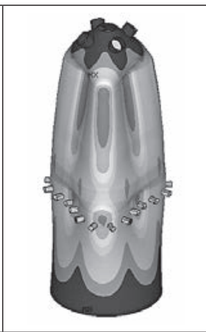
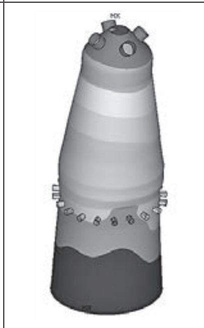
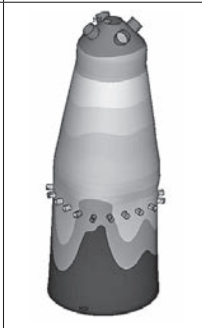
		
(a) First-order vibration type (First order cycle 0,192 s)	(b) Second order vibration type (Second order cycle 0,192 s)	(c) Third order vibration type (Third order cycle 0,162 s)
		
(d) Forth order vibration type (Forth order cycle 0,162 s)	(e) Fifth order vibration type (Fifth order cycle 0,161 s)	(f) Sixth order vibration type (Sixth order cycle 0,161 s)

Figure 4 Modal analysis result

TRANSIENT TIME HISTORY ANALYSIS

Five ground motions were selected as input excitation, denoted as W1~W5 respectively, and the damping ratio was 0,02, in order to evaluate the elastic-plastic mechanical response of the structure under earthquake action. The amplitude of ground motion is uniformly modulated to 400 gal as a rare earthquake action, and the average acceleration response spectrum of the five ground motions is shown in Figure 5.

Under the action of five seismic waves, the maximum stress position of the structure is 113,6 Mpa. The time history curve of vertex displacement is shown in Figure 6.

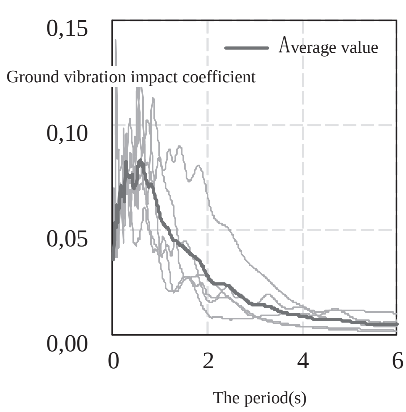


Figure 5 Average acceleration response spectrum of five seismic waves (fortified earthquake)

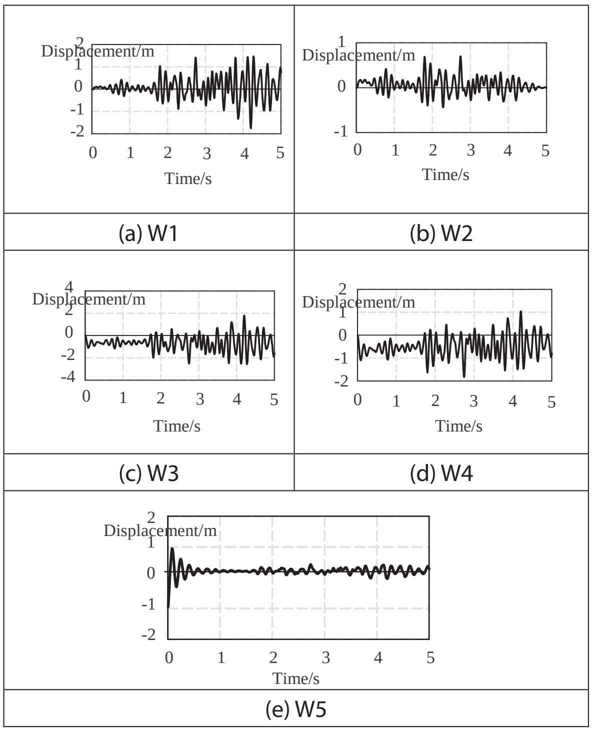


Figure 6 Time history curve of structural vertex displacement

According to the results of time history analysis, the deformation amplitude of the structure under the earthquake is controllable, the maximum stress of the structure does not exceed the yield strength, and the structure is still elastic, so the design is safe.

CONCLUSIONS

In this paper, ANSYS software is used to establish the finite element analysis model of the blast furnace shell structure. Through the static analysis, modal analysis and dynamic time history analysis, the dynamic response of the structure under the earthquake is obtained. The deformation and stress of the structure under the earthquake are controlled in a small degree, and the structure is more safe. In addition, the finite element simulation method can be used to comprehensively evaluate the deformation, stress and damage of the structure under earthquake, and the finite element method can be used to analyze the safety performance of the blast furnace shell.

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Note: The responsible translator for English language is W. Zhang, Anshan, China