C. HAN, J. YUAN, Y. Z. ZHONG, X.M. FANG, G. C. YU, H. C. JI

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Q345C STEEL WELDING PROCESS SIMULATION ANALYSIS

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In order to meet the requirements for the quality of steel structure welding projects in severe cold areas, reasonable and effective technical research and welding scheme improvement are carried out for welding in low temperature environments. Based on ABAQUS software to simulate different welding conditions, mainly for welding after traditional flame heating and ceramic sheet heating in low temperature environment, the corresponding temperature field is obtained. Compared with the actual welding results, it is concluded that the weldment welded after heating with ceramic sheet is of better quality, fully verify the accuracy of welding simulation, optimize process design, shorten the time required for practical inspection accumulation.

Keywords: Q345C; welding simulation; butt joints; temperature field

INTRODUCTION

Q345 series steel accounts for the largest proportion in the output of the medium and thick plate factory, and covers the largest range of varieties and specifications. Under the new equipment conditions, it is a technical problem that domestic medium and thick plate enterprises are concerned about to the greatest extent [1]. Excellent welding methods and techniques in mechanical welding are the key to ensuring the bearing performance of welded structures [2]. The number of welds in the medium and thick plates is large and the distribution is concentrated, which leads to the inevitable occurrence of welding defects during the welding process [3]. Combined with the above situation, the text mainly based on ABAQUS software to achieve a fast and accurate modeling simulation analysis of the whole process. The weld temperature analysis and comparison of weldment welds, to complete the blast furnace shell plate Q345C steel material welding simulation analysis and process optimization.

MODEL CREATION AND PARAMETER SETTING

Q345C steel has good strength, toughness and weldability, and is a very versatile rigid material [4], with a yield strength of 398 MPa and a tensile strength of 470~630 MPa. The steel prime and the pearlite rolling deformation direction alternate into a band distribution, with good toughness.

Before welding, in order to reduce welding stress, prevent cracks, and improve weld performance, the base metal must be preheated before welding. In order to explore the influence of different preheating conditions on the welding effect, there are two different preheating methods: traditional flame heating and ceramic electric heating. Therefore, the welding simulation simulation is carried out to enhance the reliability of the actual welding before the actual welding is carried out.

Numerical modeling begins with the meshing of a given geometry. Depending on the geometry, the meshing methods are different, the mesh size is also different, and the number of meshes determines the length of calculation time and the accuracy of the solution. As the number of mesh elements increases, the accuracy of the solution will continue to increase, and eventually an accurate solution will be obtained. The size of the entire weldment is 1 000 mm*1 000 mm*50 mm, the unit division size is 2 mm cube square, and the whole model contains 2 500 units.

The analysis of the welding temperature field requires the given temperature-dependent material parameters: density, thermal conductivity, elasticity, specific heat, density, plasticity, coefficient of thermal expansion, and initial temperature.

The welding method of Q345C steel weldment is melt inert-gas welding, and the double ellipsoidal heat source distribution function is selected as the heat source load, which can be expressed by the following formula:

$$q_1\left(x,y,z\right)=\frac{6\sqrt{3}(f_1Q)}{a_1bc\pi\sqrt{\pi}}e^{[-3(\frac{x^2}{a_1^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2})]},x\geq 0 \tag{1}$$

$$q_2\left(x,y,z\right)=\frac{6\sqrt{3}(f_2Q)}{a_2bc\pi\sqrt{\pi}}e^{[-3(\frac{x^2}{a_1^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2})]},x<0 \tag{2}$$

$$f_1+f_2=2,0 \tag{3}$$

C. Han, Y. Z. Zhong, X.M. Fang, G. C. Yu, H. C. Ji, China 22 Mcc Group Corporation Limited; J. Yuan, H. C. Ji (E-mail: jihongchao@ncst.edu.cn) College of Mechanical Engineering, North China University of Science and Technology, Hebei, Tangshan, China.

Where a_1, a_2, b, c are the heat source shape parameter model, Q is the effective power of the heat source, and $_1$ and $_2$ represent the distribution ratio of the heat source between the front and back parts. a_1 = 0,002 m, a_2 = 0,003 m, b = 0,002 m, c = 0,003 m; heat source partition coefficient $_1$ = 0,8, soldering current I = 225 A, soldering voltage U = 25 V, soldering speed v = 30 cm/min.

SIMULATION RESULTS AND ANALYSIS

It is difficult to weld the blast furnace plate in a cold area, and the plate needs to be heat treated to make the temperature of the plate meet the working conditions standard before normal welding can be carried out. The heat treatment methods include the traditional flame heating and ceramic sheet heating methods, and the welding conditions are simulated and simulated under the welding of two different methods. Traditional flame heating is to weld when the surface temperature of the plate reaches 100 °C. However, due to the factor of heating method, the temperature of the plate is not a condition of uniform heating, but a temperature gradient from the surface to the back, as shown in Figure 1.

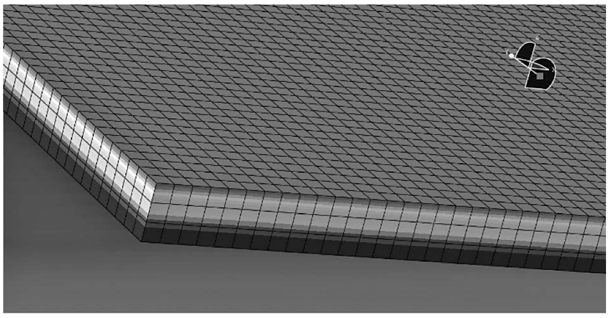
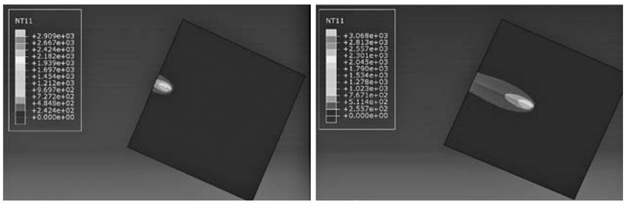
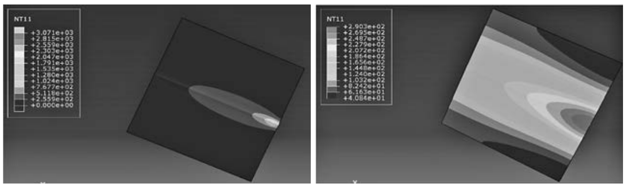


Figure 1 Temperature gradient distribution of plates after uneven heating

The entire welding process consists of three stages: arcing, smooth welding and cooling, and the welded joint refers to the entire welding area, including the weld and fusion area and the heat affected area [5]. The temperature field change of Q345C steel when welded after being heated to 100 °C by conventional flame and with uneven plate temperature distribution is shown in Figure 2. Welding is a local rapid heating and cooling process. As can be seen from the figure, when welding to 2,1 s, the maximum temperature of the welding center has reached 2 280 °C. At this time the steel is melted at high temperature and the welding consumables are fused together, and the weld is formed when the temperature drops; when welding 8,7 s, the maximum temperature of the welding center is 2 267 °C, compared with the maximum temperature difference of the welding unit at 2,1 s. After welding, the welding heat source is removed, and the overall weldment drops rapidly under the action of heat conduction, heat convection and thermal radiation, and basically returns to room temperature after a period of time.



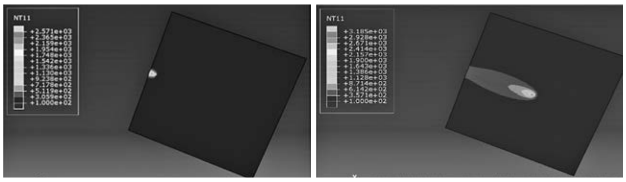
(a) t = 2,1 s (b) t = 8,7 s



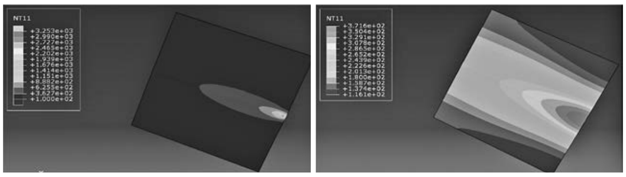
(c) t = 19.7 s (d) Cooling temperature field

Figure 2 Cloud map of the temperature field distribution of the welding process under traditional flame heating

The plate of Q345C steel is heated to ceramic sheets at a temperature environment of 5 °C so that the temperature of the weldment reaches 100 °C that the temperature distribution is uniform, then the welding begins. Therefore, the temperature field change of the weldment with a soldering temperature of 100 °C is shown in Figure 3. It can be seen from the figure that at the beginning of welding, the welding temperature field is stable, and the heat near the molten pool is almost not lost. When welding for 10 s, the maximum temperature of the welding center has reached 2 510 °C. After welding, it basically returns to room temperature after a period of cooling time.



(a) t = 0.63 s (b) t = 10 s



(c) t = 19.7 s (d) Cooling temperature field

Figure 3 Ceramic sheet heating welding process temperature field distribution cloud map

In the temperature field measurement experiment, the temperature change curve data of three groups of measuring points from the center of the weld seam are selected for verification. The weldment is unevenly heated to 100 °C by the traditional flame heating method, and the temperature change curve of the measuring points from the weld seam 0, 10 and 30 mm in the welding process is shown in Figure 4. From the welding temperature cycle curve, it can be seen that the three temperature measurement points have undergone rapid heating and cooling processes. The temperature gradient of the temperature field of the measurement point on the weld seam is large,

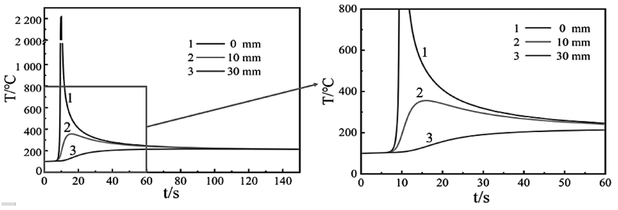


Figure 4 Characteristic point temperature change curve during welding under conventional flame heating

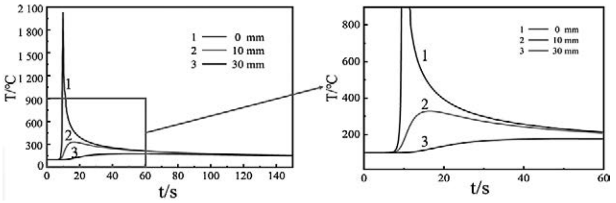


Figure 5 Characteristic point temperature change curve when welding ceramic sheet under heating

and the temperature gradient of the temperature field 30 mm from the weld measurement point is small. The weldment is heated by the ceramic sheet for uniform heating to 100 °C, and the temperature change curve of the measuring point 0, 10 and 30 mm from the weld seam in the welding process is shown in Figure 5. It can be seen from the welding temperature cycle curve that the temperature gradient of the temperature field of the measurement point on the weld seam is large. The maximum temperature gradient of the temperature field during the welding process is 2 200 °C, and the temperature gradient of the temperature field 30 mm from the weld seam measurement point is small.

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CONCLUSION

Through the study of the MIG welding process of Q345C steel plate, the modeling process of ABAQUS secondary development is completed. The welding process under different temperature fields of different preheating methods is evaluated by the relevant tests, the best welding process parameters are determined, and the best heating method is selected to ensure the welding quality. The welding temperature field of Q345C steel plate is simulated, and the simulation results that are in good agreement with the corresponding temperature field experiment are obtained, and the accuracy of the welding temperature field simulation is verified. The following conclusions can be obtained: through the temperature field analysis under different working conditions of the two, it can be concluded that the stability of the welding temperature field under the traditional flame heating is lower than that of the welding temperature field under the heating of the ceramic sheet, so the welding quality can be significantly improved by using the ceramic sheet heating method.

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Note: The responsible translator for English language is M.M. LI-North China University of Science and Technology, China