Simulation Analysis of Quenching Process of High Strength Steel Based on ABAQUS

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Abstract. With the further improvement of industrialization, construction machinery has also made considerable progress. In the field of engineering machinery manufacturing, in response to the development trend of "green manufacturing" in the country, manufacturers also want to reduce the energy consumption of construction machinery and make the products develop in the direction of light quantification, high reference quantity and long life. Therefore, users put forward higher requirements for structural steels for construction machinery. Considering the complexity of iron and steel production process at 960MPa level, we need further research and improvement of existing production processes, so as to improve the quality of domestic 960MPa steel products. In this paper, combined with the actual production of iron and steel company, through ABAQUS finite element simulation of the steel Q960 high strength quenching process in the production process of steel, a finite element model is established to simulate the temperature and stress fields of Q960 steel during quenching. The influence of temperature and pressure after quenching on the temperature and stress fields after quenching is mainly studied.

1. Introduction

The field of construction machinery is not only one of the fastest growing parts of the machinery industry, but also an indispensable part of machine manufacturing. In recent years, mechanical engineering has replaced more than 900MPa of high strength steel in the part of power, execution and support in the past. 300MPa has been replaced by high strength steel. This not only improves the mechanical performance of the whole construction, but also lightens a large part of the original weight. High strength and high toughness steel making technology is driving the development of steel metallurgy technology. The working environment of engineering machinery is complex. If the working load and static load are easy to cause the parts of the equipment to collapse, it will cause engineering accidents and cause casualties. Germany, Japan, Sweden and other countries with advanced steel enterprises have done very mature products, not only in the quality of products can be guaranteed, but also in the quantity and time of the product to get a certain guarantee. Compared with this, the domestic technology and technology are not perfect, the quality of the products is different and the supply is not guaranteed [1-2]. Therefore, the research of this paper is still of great market value. In recent years, the research of low alloy high strength steel has always been the concern of the researchers, and the technical methods are constantly improving. In recent years, the new technology of controlling rolling and controlling cooling has been gradually applied to the production process of high strength steel. Traditional heat treatment is not without market.

For most steel products with larger size and no environmental impact, original heat treatment technology is still used. In this paper, the production process of Q960 steel in Xianggang is analyzed and studied. By establishing a finite element model and using the large finite element analysis software Abaqus, the temperature field and stress field in the quenching process of Q960 high strength steel are simulated. It provides a theoretical basis for further research and has some guidance for practice production [3].

2. Selection of model

Large and efficient engineering machinery and equipment will encounter huge resistance in work. In order to ensure the safety and protection of the equipment, the support performance of the mechanical equipment needs to be strengthened, and the performance strengthening and the use of more or more high quality materials will lead to the increase of the total cost. Under the premise of ensuring green environment, we need to save energy as much as possible. Therefore, under the premise of equal strength, we should strengthen the strength of steel as much as possible, reduce the amount of steel and reduce the thickness of steel plate under the condition of strength [4-6]. In this way, the weight of the whole mechanical equipment can be reduced, the lightening degree of the equipment will be improved, and the work efficiency and energy consumption can also be improved.

Because Q960 high strength steel is often used as a steel for engineering machinery, its working condition is bad and the load is heavy. Therefore, higher requirements for its performance are put forward. Not only requires super high yield strength but also good plasticity, comprehensive mechanical properties, good weldability, high fatigue limit and certain cold shape. Therefore, the main purpose of this paper is to simulate the quenching process of Q960 structural steel and analyze the temperature field and stress field of high strength steel during quenching process [7-8].

3. The establishment of the model

3.1. 3D modeling

The thickness of Q960 high strength steel produced by Xiangtan Iron and Steel Group is mainly 10mm-40mm, and the highest yield is 20mm plate. We take the thickness of 20mm steel plate as the research object. Because the steel plate is a highly symmetrical geometry, in order to simplify the calculation without affecting the accuracy of calculation, a Q960 sheet with a length and width of 400 * 400 * 20 (mm) is intercepted on the mass production steel plate as the research object. Solidworks2016 is used for modeling. After modeling, it is saved as x.t format file [9].

3.2. Material modeling

The Q960 of Xiangtan Iron and Steel Co., Ltd. adopts low carbon equivalent design, and the design of the alloy composition makes the material have good welding performance and hardenability. And each alloying element is micro-alloyed, not only can refine the grain, but also can prevent grain boundary precipitation during tempering and reduce the temper brittleness of the material.

Q960 steel is currently the highest strength grade steel that can be mass produced in China. By adding Nb, Cr, Ni, Mo, B, Ti, etc., a small amount of microalloying elements, high-strength steel has the following advantages compared to ordinary steel: 1) Reducing the size and weight of components, reduce the workload and material consumption of welding. 2) Reducing the cost of manufacturing and transportation and installation. 3) Reducing the thickness of the steel plate, thereby reducing the thickness of the weld, improving the quality of the weld and improving the fatigue life of the structure. 4) Reducing the amount of steel, reduce the consumption of iron ore resources, and reduce the environmental damage caused by over exploitation of resources [10-11]. Therefore, as a kind of high strength steel for construction machinery, Q960 steel requires its yield strength to be more than 960MPa, and at the same time, it has good plasticity.

4. Simulation analysis of quenching process

4.1. Simulation of temperature field

According to the relevant parameters, the main performance parameters of Q960 steel plate are: density 7850 kg/m^3, linear expansion coefficient 1.05e-6/k. The Poisson's ratio is 0.3, the elastic modulus is 220GPa, and the specific heat 420J/kg· k, which has strong correlation with the temperature field analysis, has a thermal conductivity of 55 w/m· k. Only by determining the physical parameters can we correctly analyze the temperature field distribution of the material in quenching process. The grid is divided by structured grid, and the global seed size is defined as 5mm. After the division is completed, 25600 units and 32805 nodes are obtained [12]. The results show that the grid partition is of good quality, as shown in Figure 1.

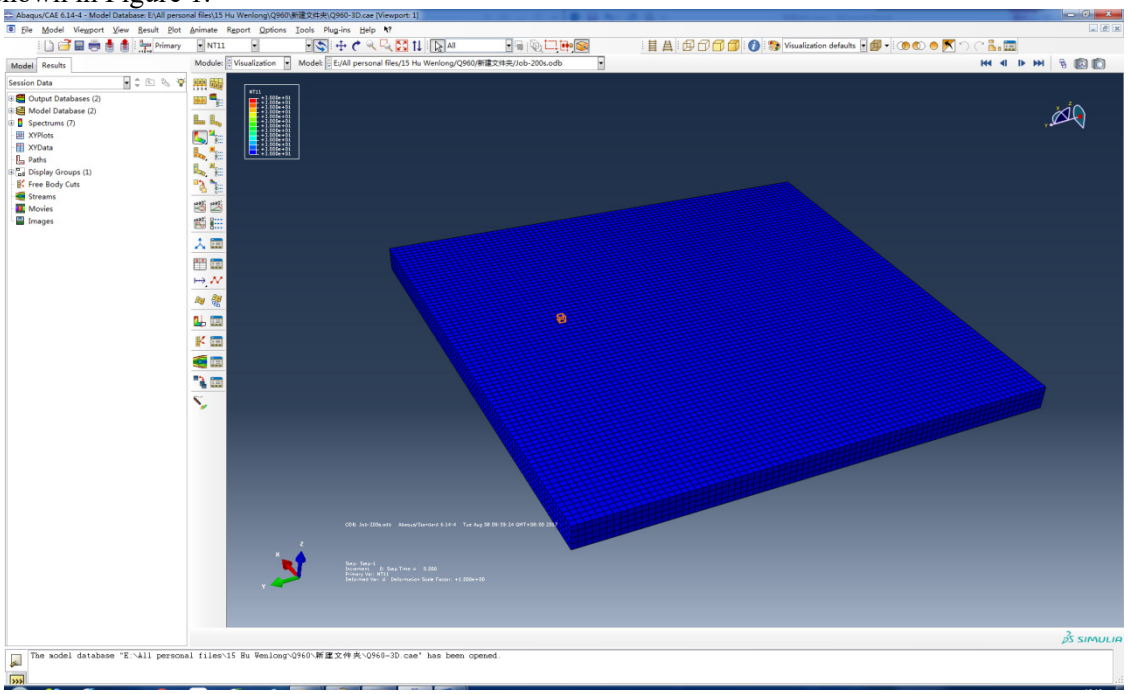

Figure 1. Q960 20mm steel plate finite element model

After completing load loading, we need to set up the model analysis step before setting up the analysis, and set up the analysis type. In this paper, the temperature field in the quenching process of Q960 steel plate is simulated and analyzed. The transient analysis step is used to simulate the temperature field and stress field, and the analysis time is set to 150s. After creating the analysis task under the Job module, you can submit the analysis. According to the influence of different air on the cooling rate of pressure and temperature in this paper, a corresponding analysis job is established: air convection pressure 0.6MPa, cooling air temperature of 10 C [13]. The simulation results of the temperature field are shown in Figures 2 and 3.

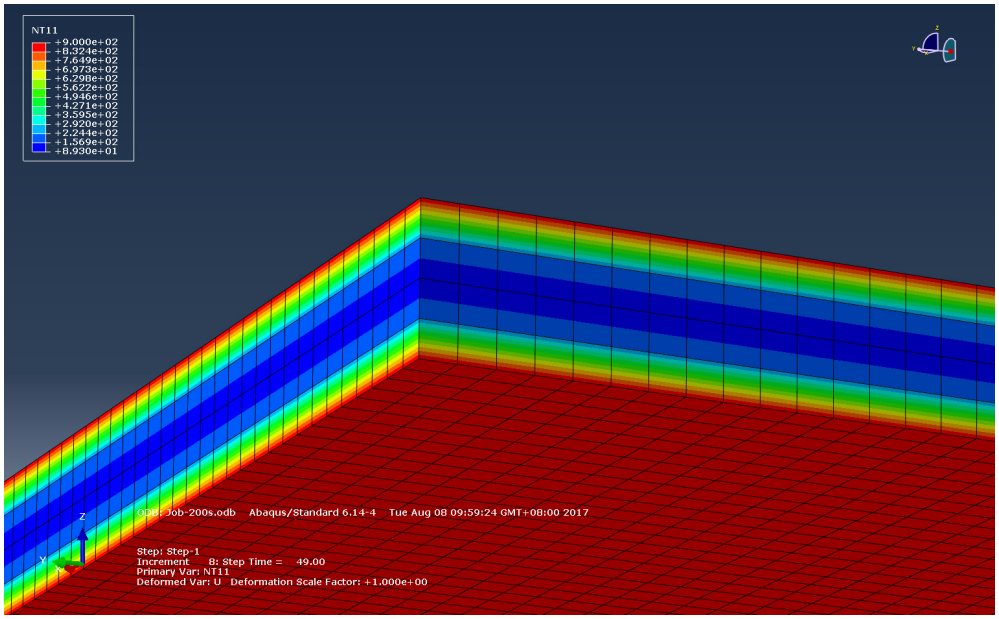

Figure 2. Temperature field distribution at t=49.00s

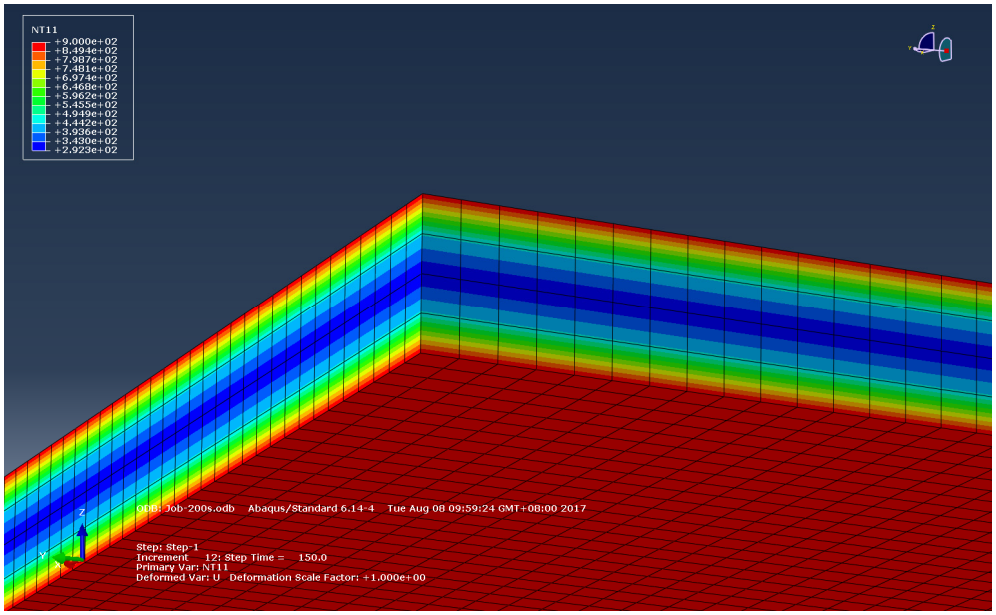

Figure 3. Temperature field distribution at t=150s

From the calculation results of the temperature field, it can be seen that the surface temperature of the steel plate directly contact with the cold quenched gas drops rapidly, which makes the surface of the steel plate quickly reach the quenching temperature. When the temperature of the steel plate has not been reduced to the required temperature, the transformation of the quenched tissue has been started, and the surface of the steel plate has been quenched to a certain depth, so that the surface of the steel plate has high strength and high wear resistance. The interior of the plate still maintains good toughness [14].

4.2. Stress field simulation

When Q960 high strength steel is quenched, the temperature changes greatly, which leads to elastic deformation. At the same time, plastic deformation also occurs. Q960 high strength steel is quenched. The uneven temperature distribution leads to stress, and the expansion of each point is different. This is

a problem of thermoelastic and thermoplastic. The thermal stress simulation of Q960 high strength steel should be simulated first by a temperature field, and then the stress field is analyzed on the basis of the simulation results. The simulated constraint loading of Q960 steel plate quenching should be completely in line with the production process. The temperature field analysis has been completed in the last chapter. This chapter is based on the temperature field solved in the previous chapter to simulate the stress field after quenching. Based on the last chapter, the simulation results of thermal stress field in job temperature field are shown in Figures 4 and 5.

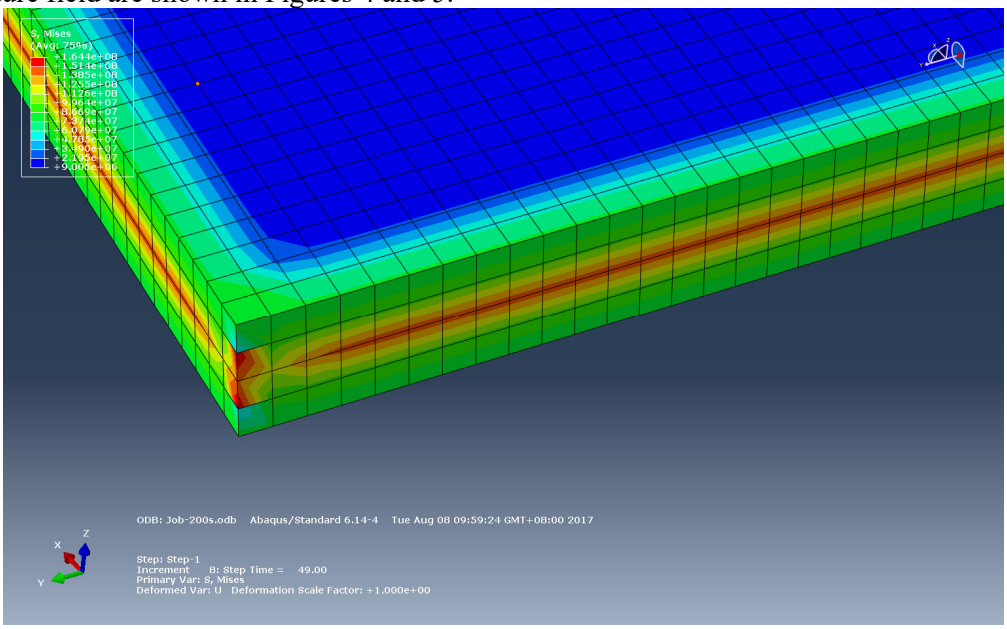

Figure 4. Thermal stress field distribution at t=49.00s

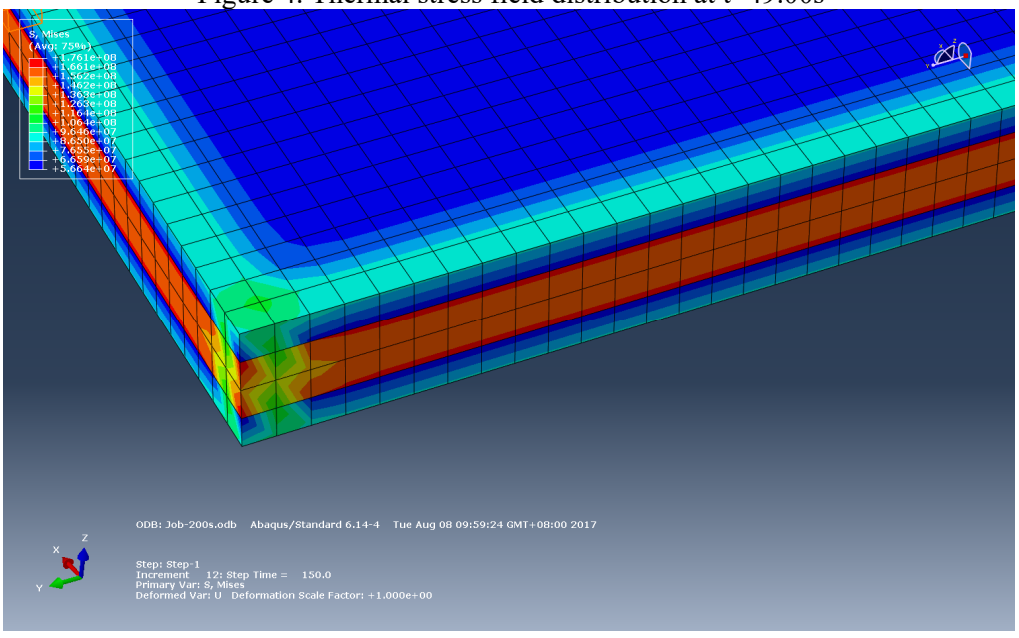

Figure 5. Thermal stress field distribution at t=150s

Through the above analysis, it can be shown that the stress change and deformation in the Q960 heat treatment process are coupled with many complicated processes, which are difficult to be measured. Generally, the stress and deformation can only be analyzed by the stress and deformation of the final heat treatment. Therefore, the finite element method to simulate the stress distribution of quenching

process of Q960 steel is very helpful for actual production.

5. Conclusion

Q960 high strength steel, because of its good comprehensive performance, can meet the requirements of the steel for engineering machinery and has high added value, which is the key research of steel in large steel works. But at present, the domestic enterprises have a shortage in the production technology of this kind of steel, so it is necessary to design a better production process to meet the needs of the steel market for construction machinery. This paper mainly combines the actual production process of Q960 steel in Xianggang, and takes 20mm thick Q960 steel as the research object. With the aid of large finite element software ABAQUS, the quenching temperature field and stress field of Q960 steel are simulated, and the influence of the pressure and temperature of the cooling medium on the quenching temperature field and the stress field during the quenching process is compared and analyzed.

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