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Normalizing and annealing of heavy steel forgings

大型锻钢件的正火与退火

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Normalizing and annealing of heavy steel forgings

1 Scope

This Standard specifies the requirements and methods for normalizing and annealing of heavy steel forgings, including pending workpiece, heat treatment equipment, heat treatment processes, heat treatment quality and inspection, calibration, safety and health requirements, energy consumption requirements, and product reports.

This Standard is applicable to normalizing and annealing of heavy steel forgings for heavy equipment that is used in industries such as energy, metallurgy and transportation.

2 Normative references

The following documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB/T 228.1, Metallic materials. Tensile testing. Part 1: Method of test at room temperature

GB/T 229, Metallic materials. Charpy pendulum impact test method

GB/T 231.1, Metallic materials. Brinell hardness test. Part 1: Test method

GB/T 6394, Determination of estimating the average grain size of metal

GB/T 7232, Terminology of metal heat treatment

GB/T 9452, Testing method for working zone of heat treatment furnace

GB/T 13298, Inspection methods of microstructure for metals

GB/T 13324, Terminology of heat treatment equipment

GB 15735, Requirements for the safety and health in production process of metal heat treatment

GB/T 16923, Normalizing and annealing of steel parts

GB/T 17358, Power consumption, measurement, and testing in heat treating production

5.1.1 For the heating of heavy steel forgings, the heat treatment furnace shall be selected according to the requirements; the heating medium is generally gas; for the workpiece which has special requirements, protective atmosphere furnace or vacuum furnace can be used.

5.1.2 Determination method of effective heating zone of the heat treatment furnace shall meet the requirements of GB/T 9452 or GB/T 30824.

5.1.3 The temperature uniformity of the effective heating zone of the heat treatment furnace for normalizing and annealing shall not exceed ±15°C; the rest shall meet the requirements of GB/T 16923 and GB/T 32541-2016.

5.1.4 The heat treatment furnace for normalizing and annealing shall be able to achieve adjustable and controllable heating rate and cooling rate.

5.2 Temperature measurement and control system

5.2.1 The type and technical requirements of the heat treatment furnace instrument system shall not be lower than the requirements of Class-D of GB/T 30825-2014.

5.2.2 The accuracy and calibration period of the instrument shall meet the requirements of Class-IV equipment in GB/T 32541-2016.

5.2.3 The selection and use of the temperature sensor shall comply with the provisions of GB/T 30825-2014.

5.2.4 The load thermocouple that is used to measure the temperature of the workpiece shall be in close contact with the workpiece; the load thermocouple shall be protected from furnace temperature radiation and furnace atmosphere.

5.3 Cooling equipment

The normalizing of heavy steel forgings is generally cooled in still air; simple cooling equipment such as fans and sprays can also be used. The cooling equipment shall uniformly cool the workpiece that is placed in the strong flowing air in all directions as far as possible; the wind speed and air volume shall meet the cooling rate that is required by the process.

6 Heat treatment process

6.1 Normalizing

6.1.1 Use

6.1.1.1 For large medium-low carbon steel and low-alloy forged steel parts, normalizing destressing and refinement structure are generally adopted; for

6.1.3.1 The workpiece shall hold a sufficient period of time when it is heated to the normalizing temperature, so as to ensure that the structure is completely transformed into austenite. The holding time shall include two processes, namely soaking and austenitizing.

6.1.3.2 The soaking time is generally estimated by half of the austenitizing holding time. If necessary, a thermocouple can be added at the thickest section of the workpiece. After the thermocouple temperature reaches the normalizing temperature, the soaking process ends. When multiple thermocouples are added to the surface of the workpiece, the soaking process shall be completed when the temperature of all thermocouples reaches the normalizing temperature.

6.1.3.3 Under normal circumstances, for ordinary carbon steels and alloy steel forgings whose effective thickness is 100 mm, the austenitizing holding time is estimated to be 0.8 h ~ 1.8 h; for medium-high alloy steels or martensitic stainless steel forgings whose effective thickness is 100 mm, it can be estimated to be 1 h ~ 2 h.

6.1.4 Cooling

6.1.4.1 Normalizing cooling of heavy steel forgings is generally carried out in air; for heavy steel forgings whose alloy content is low, methods such as blasting, spraying may be used to adjust the cooling rate.

6.1.4.2 During the normalizing cooling of heavy steel forgings, control the final cooling temperature. The final cooling temperature shall ensure that the austenite is fully transformed during the cooling process; however, it shall not be too low to avoid cracking and white spots on the workpiece.

6.1.4.3 After the workpiece is cooled to the final cooling temperature, it shall be tempered in time. The tempering parameters can be determined by reference to the quenching and tempering of heavy steel forgings.

6.2 Annealing

The classification, process parameters, effects and applications of the common annealing processes for heavy steel forgings are shown in Table 2. For annealing heating, refer to 6.1.2.

Table 2 -- Classification, process parameters, effects and applications of annealing

Classification	Process parameters	Effects	Applications
Incomplete annealing	Heating temperature: the hypoeutectoid steel is Ac_1 ~	Refine grains; improve microstructure;	It applies to hypereutectoid steel workpiece and

6.3.2.5 After the workpiece has been insulated at the specified temperature, it shall be cooled according to the methods that are specified in the process. When the workpiece is cooled in the air after being discharged from the furnace, the workpiece shall be padded and leveled to ensure air circulation around and up and down the workpiece. If blast or spray is required, it shall be ensured that the workpiece is evenly cooled.

6.3.3 Record

6.3.3.1 Record the used production equipment, temperature record, workpiece placement position and lifting method in detail during production.

6.3.3.2 All records shall be signed and confirmed by relevant operators at the end of the operation.

6.3.3.3 All records shall be retained, so as to ensure traceability of the quality of the workpiece.

7 Heat treatment quality and inspection

7.1 Inspection items and methods

7.1.1 Surface inspection

After the heat treatment, the surface of the workpiece shall be visually inspected, so as to ensure that the surface is free from cracks and scratches. If necessary, carry out infiltration, magnetic powder or ultrasonic flaw detection according to relevant standards.

7.1.2 Surface hardness

If the purchaser has regulations, the surface hardness of the workpiece shall meet the requirements of the technical documents. The detection location, test methods and acceptance requirements of surface hardness shall be indicated in the technical documents. The surface hardness test of the workpiece shall be carried out in accordance with the requirements of GB/T 231.1 or GB/T 17394.1.

7.1.3 Size inspection

After heat treatment, use corresponding instrument and gauge to measure the workpiece size. The workpiece size must meet the final delivery size of the workpiece.

7.1.4 Non-destructive testing

7.3.2.1 If the mechanical properties are still unqualified, it is allowed to have re-heat treatment.

7.3.2.2 After re-heat treatment, the workpiece shall be resampled for mechanical property testing.

7.3.2.3 The number of re-heat treatments is generally not more than two; if it is otherwise specified in the contract, perform as required by the contract.

8 Calibration

8.1 The workpiece should be calibrated during normalizing and cooling.

8.2 When the workpiece uses normalizing and tempering as the performance heat treatments, if it needs to be calibrated after tempering, the calibration process shall be carried out at a temperature at least 55°C lower than the final tempering temperature. After the calibration, the stress relief treatment shall be performed at a temperature 30°C ~ 55°C lower than the final tempering temperature.

8.3 The interception and performance test of the sample shall be carried out after the completion of the destressing process after the calibration.

9 Safety and health requirements

The safety and health of normalizing and annealing are carried out in accordance with the relevant provisions of GB 15735.

10 Energy consumption requirements

The energy consumption quota of normalizing and annealing processes shall comply with the relevant provisions of GB/T 17358 and GB/T 19944.

11 Product reports

Reports can be issued on a per-batch or per-furnace basis as required. The report shall include the following:

a) heat number;

b) product name or code;

c) process type or process code;

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