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**Heat Treatment for Stainless Steel and Heat Resistant
Steel Parts**

不锈钢和耐热钢件热处理

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Table of Contents

Foreword.....	3
1 Scope.....	4
2 Normative References	4
3 Terms and Definitions	5
4 Classification of Common Stainless Steel and Heat-Resistant Steel.....	5
5 Heat Treatment Method and Process	7
6 Equipment.....	15
7 Process.....	16
8 Quality Control and Inspection.....	20
9 Safety and Environmental Health	21
10 Requirements for Energy Consumption.....	21

Heat Treatment for Stainless Steel and Heat Resistant Steel Parts

1 Scope

This Standard specifies requirements for common materials, heat treatment methods and processes, heat treatment equipment, processes, quality control and inspection, safety and environmental health, energy consumption, etc. of stainless steel and heat-resistant steel parts.

This Standard is applicable to the heat treatment of stainless steel and heat-resistant steel parts used in the equipment manufacturing industry. Other industries can be implemented by reference of it.

2 Normative References

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this document.

GB/T 7232 Terminology of Metal Heat Treatment

GB/T 9452 Testing Method for Work Zone of Heat Treatment Furnace

GB 15735 Requirements for the Safety and Health in Production Process of Metal Heat Treatment

GB/T 17358 Power Consumption Measurement and Testing in Heat Treating Production

GB/T 20878 Stainless and Heat-Resisting Steels - Designation and Chemical Composition

GB/T 27946 Limited Value of Hazardous Substance in the Air of Heat Treatment Working Place

GB/T 30822 Environmental Protection Technical Requirements for Heat Treatment Industry

GB/T 30825 Pyrometry for Heat Treatment

GB/T 32529 Technical Requirement of Cleaning Liquid Waste Recycling and Emissions for Heat Treatment

GB/T 32541 Quality Control System for Heat Treatment

JB/T 10457 Technological Requirements of Liquid Quenching Apparatus

3 Terms and Definitions

For the purpose of this document, the terms and definitions given in GB/T 7232, GB/T 20878 and the following apply.

3.1 Heat-treatable steel

Steel whose strength can be significantly improved by proper heat treatment.

3.2 Non-heat-treatable steel

Steel whose strength can't be significantly improved by proper heat treatment.

3.3 Adjusting heating treatment

Solution treatment that is performed to change the martensite transformation point of precipitation hardening stainless steel.

3.4 Stabilizing treatment

Heat treatment that is performed to improve the corrosion resistance and the stability in shape or size of steel.

NOTE: The stabilizing treatment includes stabilization annealing and stabilization tempering treatment.

4 Classification of Common Stainless Steel and Heat-Resistant Steel

Stainless steel and heat-resistant steel are divided into non-heat-treatable steel and heat-treatable steel according to the heat treatment; and are divided into austenitic, ferritic, martensitic, austenite-ferritic and precipitation hardening stainless steels according to the microstructure. The classification of common stainless steel and heat-resistant steel and the comparison between new and old designations are shown in Table 1. The chemical composition of steel in Table 1 shall comply with the provisions of GB/T 20878.

5.2.1.1 For the workpieces that require to eliminate the processing stress, reduce the hardness and increase the plasticity, as well as to improve the cutting performance of steel and obtain the best structure, annealing, two-stage annealing or multi-stage annealing may be carried out.

5.2.1.2 For workpieces that require improvement of the original structure, the normalizing + high temperature tempering of preparing heat treatment may be carried out.

5.2.1.3 For the precipitation hardening stainless steel workpieces for important purposes, they shall be dehydrogenated to eliminate the effects of hydrogen embrittlement.

5.2.2 Final heat treatment

5.2.2.1 For workpieces that require to improve strength, hardness and corrosion resistance, the quenching + low temperature tempering shall be carried out.

5.2.2.2 For workpieces that require high strength and elastic limit, and do not require high corrosion resistance, the quenching + medium temperature tempering shall be carried out.

5.2.2.3 For workpieces that require good comprehensive mechanical properties and certain corrosion resistance, quenching + high temperature tempering shall be carried out.

5.2.2.4 For precipitation hardening stainless steel workpieces that require good comprehensive mechanical properties and corrosion resistance, adjusting heat treatment such as solid solution + aging, solid solution + cold treatment or cold deformation + aging may be carried out.

5.2.3 Re-heat treatment

5.2.3.1 When the mechanical properties of stainless steel or heat-resistant steel parts do not meet the requirements after heat treatment, re-heat treatment may be performed. However, the number of repeated quenching or solution treatments shall not exceed twice. Complementary tempering of the workpiece is not regarded as a re-heat treatment.

5.2.3.2 The martensitic stainless steel and heat-resistant steel in the quenched state or after low temperature tempering shall be preheated, annealed or high temperature tempered before repeated quenching.

5.3 Fusion welding assembly

5.3.1 For the fusion welding assembly that is composed of heat-treatable stainless

6 Equipment

6.1 Heating equipment

6.1.1 Stainless-steel and heat-resistant steel workpieces may be heated by air resistance furnace, protective atmosphere furnace, vacuum furnace, etc. For finished workpieces, thin-walled workpieces, bolts, etc., it shall be heated in a protective atmosphere furnace or a vacuum furnace. The quenching (solution) treatment of precipitation hardening stainless-steel finished parts shall use a vacuum furnace.

6.1.2 The temperature of the effective heating zone of the heating furnace shall be measured according to the method specified in GB/T 9452. The heating furnace for quenching and tempering shall be no lower than the Class-III furnace; and the heating furnace for the aging treatment of precipitation hardening stainless-steel and heat-resistant steel shall be no lower than the Class-II furnace. The temperature uniformity inspection cycle shall comply with the provisions of GB/T 30825 and GB/T 32541.

6.1.3 The temperature monitoring system of the heating furnace shall comply with the relevant provisions of GB/T 32541; and each heating zone shall be equipped with temperature instruments for automatic control, recording and alarm.

6.1.4 The instrument type and system accuracy requirements and calibration period of the heating furnace shall comply with the relevant provisions of GB/T 32541.

6.1.5 The atmosphere in the protective atmosphere heating furnace shall be adjustable and controlled. When the protective atmosphere enters the heating furnace, it shall not directly scour the workpiece and adversely affect the workpiece. When the temperature is lower than 770°C, nitrogen may be used as a protective atmosphere; but nitrogen decomposed from ammonia shall not be used as a protective atmosphere. When the temperature is higher than 770°C, nitrogen shall not be used as a protective atmosphere for annealing or solution treatment.

6.1.6 The pressure rise rate of the vacuum furnace shall be less than 1.33Pa/h, when the vacuum degree is higher than 0.13Pa; the vacuum degree and atmosphere in the furnace shall be adjusted according to the requirements of the heat treatment process.

6.2 Cooling equipment

6.2.1 The cooling equipment shall comply with the provisions of JB/T 10457.

6.2.2 The volume of the cooling device shall ensure sufficient cooling capacity under continuous production conditions.

6.2.3 The cooling device shall be equipped with a cooling cycle system and a stirring device (compressed air stirring is prohibited); and a heating device shall be equipped

7.2.5 Clean up by sandblasting or shot peening.

7.3 Furnace loading

7.3.1 The workpiece shall be placed in the effective heating zone of the heating furnace.

7.3.2 Special fixtures shall be used for workpieces that are prone to deformation during heat treatment.

7.3.3 The material pan, material basket or fixture shall be made of stainless steel or heat-resistant steel.

7.3.4 The temperature of the furnace loading shall not exceed the specified tempering temperature during the tempering period.

7.4 Heating

7.4.1 For workpieces with complex shapes or sharp changes in cross-sections and large effective thicknesses, the heating rate shall be controlled; and preheating shall be carried out, if necessary, to reduce deformation and prevent cracking. The preheating methods include:

- a) One-stage preheating: 800°C ~850°C;
- b) Two-stage preheating: 500°C ~650°C and 800°C ~850°C.

7.4.2 There shall be enough heat preservation time for the heating of the workpiece. The start time of heat preservation shall be calculated from the last recording thermocouple in the work area reaching the lower limit of the setting temperature.

7.4.3 The length of the heat preservation time may be adjusted according to the shape and size of the parts, heating temperature, heating medium, heating method, furnace loading method, and furnace loading volume, etc. For the workpieces after preheating, the heat preservation time may be appropriately shortened.

In general, the methods for determining the heat preservation time include:

- a) In the case of single-layer bulk, the heat preservation time shall be calculated according to the effective thickness or conditional thickness of the workpiece, see Table 6. While the effective thickness or conditional thickness is the actual thickness multiplied by the shape factor of the workpiece, see Table 7.
- b) In the case of dense stacking, the heat preservation time shall be calculated according to the maximum stacking effective thickness or the conditional thickness of the workpiece. When the furnace load has a greater influence on the heat transfer, it is allowed to increase the heat preservation time according to the furnace loading coefficient of the workpiece; that is, the heat preservation

7.5.2 After the martensitic stainless steel and heat-resistant steel is quenched and cooled off to the room temperature, they may be cleaned, cold treated or tempered.

7.5.3 After the martensitic stainless steel and heat-resistant steel workpieces are quenched, they shall be tempered in time; and the time interval shall not exceed 4h.

7.5.4 For fusion welded assemblies that are composed of martensitic stainless steel and heat-resistant steel, the time interval between welding and subsequent heat treatment shall not exceed 4h.

7.6 Calibration

7.6.1 The workpiece shall be calibrated under static load conditions; and it is generally not suitable to knock locally.

7.6.2 After the martensitic stainless steel and heat-resistant steel workpieces are calibrated, they shall be subjected to stress-relief annealing at a temperature lower than the original tempering temperature.

7.6.3 When tempering workpieces with complex shapes or strict size requirements, use a shaping fixture and tempering for calibration.

7.6.4 After the austenitic stainless-steel workpiece is calibrated, perform stress-relief annealing at a temperature below 300°C.

8 Quality Control and Inspection

8.1 The quality control requirements of the heat treatment process shall comply with the provisions of GB/T 32541.

8.2 The workpiece shall be inspected according to the items and requirements specified in the corresponding technical documents.

8.3 The original record of heat treatment shall be filled in as required and kept properly.

8.4 According to requirements, a quality report may be issued for each batch or furnace. The content of the report includes but not limited to:

- The name and drawing number of the workpiece;
- Technical requirements of the product;
- The material designation of the workpiece;
- single piece weight and quantity;

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