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Gas nitriding of steel parts

钢件的气体渗氮

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Gas nitriding of steel parts

1 Scope

This standard specifies the gas nitriding process, equipment, inspection, energy consumption and safety and health requirements for heating steel parts, in an ammonia-containing atmosphere.

This standard applies to gas nitriding of carbon steel, alloy structural steel, alloy tool steel, stainless steel, heat-resistant steel.

2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For the dated references, the subsequent amendments (excluding corrections) or revisions do not apply to this Standard; however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB 536-1988 Anhydrous ammonia

GB/T 699 Quality carbon structural steels

GB/T 700 Carbon structural steels (GB/T 700-2006, ISO 630:1995, NEQ)

GB/T 1182 Geometrical product specifications (GPS) - Geometrical tolerancing - Tolerances of form orientation location and run-out (GB/T 1182-2008, ISO 1101:2004, IDT)

GB/T 1220 Stainless steel bars

GB/T 1221 Heat-resistant steel bars

GB/T 1299 Alloy tool steels

GB/T 3077 Alloy structure steel

GB/T 7232 Terminology of metal heat treatment

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

GB/T 9943 High-speed tool steel

6 Preparatory heat treatment

6.1 The preparatory heat treatment of the parts for nitriding shall be carried out, according to the requirements of the workpiece for the performance of the base material. Generally, quenching and tempering or normalizing is used. The 38CrMoAl steel must be tempered; meanwhile it shall ensure that the austenite on the surface of the workpiece is transformed into martensite, during tempering and quenching.

6.2 For workpieces that are easily distorted, stress relief annealing shall be performed, after quenching & tempering and rough machining. Its temperature shall be lower than that of quenched and tempered high temperature tempering AND higher than that of nitriding.

6.3 Tool and die steels are generally quenched and tempered. In addition to quenching and tempering treatment of stainless steel and heat-resistant steel, austenitic stainless steel can also be subject to solid solution treatment.

6.4 The metallographic structure, hardness and distortion of the workpiece, after preparatory heat treatment, shall meet the technical requirements and process requirements. The amount of free ferrite, within 5 mm of the surface of 38CrMoAl steel, after quenching and tempering, shall not exceed 5% (area fraction, equivalent to grades 1 ~ 2 of GB/T 11354-2005); meanwhile it is not allowed for tempered structure or pearlite structure, which contains granular bainite or upper bainite.

6.5 There shall be no defects, such as cracks, decarburization, poor carbon, scratches, bumps and stains, on the surface of the workpiece.

6.6 After the workpiece is straightened, stress relief annealing shall be performed.

7 Gas nitriding equipment and process materials

7.1 Nitriding furnace

7.1.1 The effective heating area of the furnace shall be measured, according to the provisions of GB/T 9452. The actual temperature deviation (referring to the effective charging area in the furnace) shall not exceed ±5 °C.

7.1.2 Various materials inside the furnace (referring to those in contact with the atmosphere) shall not have a harmful effect on the stability of the nitriding atmosphere.

7.1.3 The furnace chamber shall be well sealed. There shall be no leakage in

the furnace atmosphere; the furnace gas shall flow smoothly through the nitriding parts.

7.1.4 The furnace shall be equipped with an ammonia decomposition rate measuring device. Ammonia decomposition rate shall be adjusted, according to process requirements.

7.1.5 The temperature control system shall ensure that the furnace temperature meets the technological requirements.

7.1.6 The sealed box type nitriding furnace and the pushing tray type nitriding furnace must have reliable explosion-proof devices.

7.1.7 The nitriding furnace must have a complete waste gas treatment device. It is not allowed to directly discharge or ignite the waste gas, which contains ammonia, into the atmosphere. The waste gas can be discharged, after fully decomposing the ammonia in the waste gas, by passing it through an ammonia decomposer, which has a temperature up to above 750 °C AND is equipped with catalyzer; OR it can be discharged after passing the waste gas into water to make the ammonia be absorbed; the waste water in the container, which absorbs the ammonia, shall not be directly discharged, but be added with acid for neutralization; the neutralized ammonia shall be recycled.

7.2 Ammonia

7.2.1 The quality of ammonia, which is used for nitriding, shall meet the requirements of grade-1 products in GB 536-1988.

7.2.2 Liquid ammonia shall be filled in steel cylinders (tanks), that meet the requirements of national standards. The liquid ammonia cylinder shall be placed in a separate room, where fireworks are strictly prohibited; the ammonia cylinder shall be prevented from violent impact and sunlight exposure. Liquid ammonia and liquid ammonia cylinders shall have a quality assurance sheet from the manufacturer.

7.2.3 The connection between the nitriding furnace, the ammonia transmission pipeline and the ammonia cylinder shall ensure the tightness.

7.3 Temperature measurement and temperature control

7.3.1 The temperature control system, that meets the requirements of JB/T 10175, shall be configured, according to the requirements of the gas nitriding process.

7.3.2 A temperature recording device shall be equipped to track and display the heating temperature.

c) Plating a non-porous copper layer of more than 0.02 mm;

d) Plating a nickel-layer of 0.02 mm ~ 0.04 mm;

e) Coated anti-seepage paint shall comply with the provisions of JB/T 9199.

8.3 Surface requirements before treatment

8.3.1 The surface roughness of the workpiece shall meet the requirements of the drawing. The surface shall be clean. There shall be no grease, dirt, rust, scratches, bumps, stains, etc. It shall not have sharp edges and corners.

8.3.2 The machining allowance of the workpiece shall comply with the process requirements. Usually, the grinding allowance of the nitrided surface of the structural part shall not exceed 0.05 mm on one side.

8.3.3 For stainless steel parts, fine sandblasting can be used to remove the passive film (other methods can also be used).

8.3.4 The parts for nitriding shall be subject to rolling, ultrasonic shot peening or other cold plastic deformation processing in advance, before nitriding treatment.

8.4 Specimen

8.4.1 Except for small pieces, usually each furnace of parts for nitriding shall be accompanied by furnace specimens. The specimen shall be consistent with the steel designation, preparatory heat treatment process, surface roughness of the part for nitriding. The sample size is generally Φ20 mm ~ Φ30 mm; the thickness is 4 mm ~ 10 mm.

8.4.2 The specimens of important workpieces shall be taken from the parts for nitriding.

8.5 Furnace loading

8.5.1 When inspecting the fixtures for loading of furnace, if any problems such as embrittlement, cracking or unsatisfactory shape are found, they shall be repaired or replaced in time.

8.5.2 Install the parts for nitriding, on the fixture stably and securely, according to the process requirements.

8.5.3 Install the parts for nitriding, in the effective heating area steadily and firmly; keep a proper distance from each other, to ensure the circulation of the atmosphere and the uniform temperature.

8.5.4 According to the size of the furnace chamber, it shall suspend 3 ~ 10

computer control system, to see whether they are in normal state.

8.7.3 After the above inspection work is completed, it may strictly adjust and control the process parameters, such as heating rate, holding temperature, holding time, ammonia decomposition rate (nitrogen potential), according to the process requirements.

8.7.4 For workpieces that are slender, thin-walled, asymmetrical, subject to sharp changes in cross-sectional size, it shall appropriately control the heating rate. It may adopt the staged temperature increase method, to keep it at 460 °C ~ 470 °C for a certain period of time; after the temperature in the furnace is uniform, it is raised to the nitriding temperature.

8.7.5 Lead in ammonia or nitrogen gas into the furnace chamber, to fully discharge the air in the furnace.

8.7.6 In the whole nitriding process, it shall always maintain the tightness of the furnace chamber. The cooling and discharging after nitriding vary, according to the specific situation. The workpieces, that are easy to be distorted, need to be cooled slowly; for the workpieces, that are not easily distorted, it does not need to have strict requirements on the cooling rate, but focus on the production efficiency. The residual ammonia in the furnace shall be removed, before the workpiece is discharged; then the furnace door shall be opened. Short-term nitriding generally adopts oil cooling, whilst austenite nitriding must adopt oil quenching or isothermal quenching.

8.7.7 In the event of a power failure during the nitriding process, ammonia gas shall continue to be fed into the furnace, when the furnace temperature is not lower than 400 °C. After the power supply is restored, the temperature is raised to the specified process temperature.

8.7.8 The nitriding parts shall avoid calibration as much as possible. If correction is necessary, stress relief annealing and flaw detection shall be carried out immediately afterwards. For the workpieces with excessive distortion after nitriding, they need thermal correction. The straightening heating temperature shall be lower than the nitriding temperature. The important parts shall not be straightened after nitriding.

8.7.9 In order to maintain the stability of ammonia decomposition rate, in the furnace, after long-term use of the furnace, the furnace chambers, internal components, fixtures, shall be subject to denitrification treatment regularly. Denitrification can be carried out after the furnace is turned off. The furnace is heated to 600 °C ~ 650 °C; the empty burning is for 4 h ~ 6 h.

9.2 Inspection method

9.2.1 Appearance inspections, such as cracks and fractures, can be identified by naked eyes, or by magnetic particle or penetrant inspection methods. The latter shall comply with the provisions of GB/T 15822.2 and JB/T 9218.

9.2.2 The surface hardness test shall be carried out, in accordance with the provisions of JB/T 6050.

9.2.3 For the brittleness inspection of the nitrided layer, the porosity inspection of the nitrided layer, the inspection of nitrides in the nitrided diffusion layer, the measurement depth of the nitrided layer, the metallographic structure inspection, they shall be carried out in accordance with the provisions of GB/T 11354-2005.

9.2.4 The corrosion resistance test of corrosion-resistant nitriding shall be carried out, according to the provisions of GB/T 10125. It may also use one of the following two methods, to test the corrosion resistance of corrosion-resistant nitrided parts:

a) Immerse the specimen in a 6% ~ 10% $CuSO_4$ aqueous solution OR drop the above solution on the surface of the specimen or the workpiece to be tested, for a duration of 1 min ~ 2 min; if no copper is deposited, it is judged as qualified.

b) Dissolve 10 g of $K_3Fe(CN)_6$ (red blood salt) and 20 g of NaCl in 1 L of distilled water; immerse the nitriding specimen in the above solution for 1 ~ 2 min; if there is no blue mark, it is qualified.

10 Energy consumption requirements

The energy consumption quota of gas nitriding shall comply with the relevant requirements of GB/T 17358 and GB/T 19944.

11 Safety and health requirements

The safety and health requirements of the gas nitriding process shall comply with the relevant provisions of GB 15735.

12 Product report sheet

12.1 Report sheet can be issued for each batch or each furnace, as required.

12.2 Contents of the product report sheet:

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