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Test methods for detecting detrimental phase in lean duplex austenitic-ferritic stainless steels

经济型奥氏体-铁素体双相不锈钢中有害相的检测方法

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Test methods for detecting detrimental phase in lean duplex austenitic-ferritic stainless steels

1 Scope

This standard specifies the test methods for detecting detrimental phase in three types of lean duplex austenitic-ferritic stainless steels, namely the microstructure testing method, the Charpy impact test method, the ferric chloride corrosion test method.

This standard applies to the testing of precipitated detrimental phase in lean duplex austenitic-ferritic stainless steel in the production, manufacturing process (such as heat treatment or welding) or long-term use at a certain temperature. It does not apply to the situations where the toughness and corrosion resistance of lean duplex austenitic-ferritic stainless steel are reduced due to other reasons. Refer to Appendix A for the main applicable product designations of this standard.

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 standard.

GB/T 229 Metallic materials - Charpy pendulum impact test method

GB/T 2650 Impact test methods on welded joints

GB/T 13298 Inspection methods of microstructure for metals

GB/T 17897 Corrosion of metals and alloys - Corrosion test for pitting corrosion resistance of stainless steels in the ferric chloride solution

GB/T 30067 Standard terminology relating to metallography

3 Terms and definitions

The terms and definitions as defined in GB/T 30067 as well as the following terms and definitions apply to this document.

3.1

Lean duplex austenitic-ferritic stainless steel

A low-cost duplex austenitic-ferritic stainless steel which has a ferrite content of 35% ~ 65%, a typical composition of low carbon, low molybdenum ($\text{Mo} < 2\%$), high chromium ($\text{Cr} > 17\%$), is added with nickel, manganese, nitrogen alloy elements.

Note: Lean duplex stainless steel has excellent toughness, weldability, high strength and resistance to chloride stress corrosion.

3.2

Detrimental phase

The nitride (Cr_2N), carbide (Cr_{23}C_6), χ phase and a small amount of σ phase as formed in lean duplex austenitic-ferritic stainless steel at a certain temperature.

3.3

Boundary percentage content of the detrimental phases

P

The percentage content of phase boundary area of the detrimental phase accounting for the total phase boundary area.

Note: The P value reflects the degree of precipitation of detrimental phases on the phase boundary; it directly affects the toughness and corrosion resistance of duplex stainless steel.

3.4

Pitting resistance equivalent number

PREN

The parameters that comprehensively characterize the corrosion resistance of stainless steel, which are related to the chemical composition and expressed in% (mass fraction).

Note: $\text{PREN} = \% \text{Cr} + 3.3\% \text{Mo} + 16\% \text{N}$.

3.5

20Cr type group A

- b) Charpy impact test method: Used to detect the presence of detrimental phases in duplex stainless steel and their influence on impact performance;
- c) Ferric chloride corrosion test method: Used to detect the presence of detrimental phases in duplex stainless steel and its influence on corrosion resistance.

5.1.2 The three test methods are only used to detect the presence of detrimental phases and their influence on the impact performance and corrosion resistance of duplex stainless steel; they cannot specifically determine the specific structure of the detrimental phase. The microstructure testing method is suitable for various occasions and samples of various shapes, especially for the evaluation of the performance of special profiles and in-service components.

5.2 Microstructure testing method

5.2.1 Specimen preparation

The test surface of the specimen shall not be less than 400 mm². The preparation and etching of the specimen shall be carried out in accordance with the provisions of GB/T 13298. The specimens should be electrolytically etched; the recommended etchant and electrolytic parameters are as shown in Table 2.

5.2.2 Magnification

The magnification is 500 x; if necessary, it can be combined with 1000 x for evaluation.

Table 2 -- Electrolytic etching reagents and electrolytic parameters

5.2.3 Testing method

5.2.3.1 Comparison method

5.2.3.1.1 Select the most serious field of view on the testing surface and compare it with the rating chart in Appendix B, to evaluate the amount of detrimental phase precipitation. The detrimental phase's rating chart is divided into two series, I and II. The 20Cr type Group A uses the I series chart and the 20Cr type Group B uses the II series chart. When the amount of detrimental phase precipitation is between the two evaluation charts, choose the closest

temperature shall be fully removed by grinding or machining. Remove the sharp corner burrs of the specimen, to ensure a smooth transition between the edges and sharp corners of the specimen. All sample surfaces shall be smooth.

5.4.2.2 The surface roughness of the specimen shall be consistent, meanwhile the R_a shall not be less than $0.8\ \mu\text{m}$. The processing shall be cooled to avoid overheating of the surface.

5.4.2.3 For pipe fittings, the inner surface shall remain the original surface, but the cut surface and outer surface shall be uniform and smooth, meanwhile the surface roughness R_a shall not be less than $0.8\ \mu\text{m}$.

5.4.2.4 For special-shaped products such as steel bars, etc., due to the special reasons of the actual shape, the specimen shall maintain the original surface, but the cut surface shall be uniform and smooth, meanwhile the surface roughness R_a shall not be less than $0.8\ \mu\text{m}$.

5.4.2.5 The polished surface of the specimen shall neither be treated with chemical passivating agents such as nitric acid, citric acid or phosphoric acid, nor can it be treated with nitric acid, hydrofluoric acid mixtures or other acid solutions.

5.4.2.6 The specimen shall be rinsed with water, rinsed with alcohol or acetone, then blown dry. The weighing accuracy of the specimen shall not be less than $0.0001\ \text{g}$. Before the test, the specimen shall be stored in a dry container.

5.4.3 Test device and preparation of corrosion solution

5.4.3.1 Test device

5.4.3.1.1 1000 mL glass beaker or 1000 mL long or conical flask or other suitable container.

5.4.3.1.2 Constant temperature water bath or salt bath.

5.4.3.2 Preparation of corrosion solution

5.4.3.2.1 Dissolve 55.1 g of ferric chloride solvent ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) and 6.6 g of sodium nitrate (NaNO_3) in 600 mL distilled water (the mass is close to 5% FeCl_3 and 1% NaNO_3). Use glass fiber or filter paper to filter it, to remove undissolved particles.

5.4.3.2.2 The volume of the solution is calculated as not less than 150 mL or 20 mL solution per square centimeter of the specimen surface, whichever is larger.

5.4.4 Test method

5.4.4.1 The test method shall be carried out in accordance with the provisions

5.4.5.2.3 When the test temperature is higher than $23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$, meanwhile the corrosion rate of the specimen is greater than the allowable value in Table 4, the test shall be repeated at the test temperature. If it meets the requirements of Table 4, it is deemed qualified.

5.4.5.2.4 The supplier may re-solutionize the duplex stainless steel that fails the corrosion test and re-do the test.

6 Test report

6.1 The test report shall include the following:

- a) Steel designation and heat number;
- b) Sampling location;
- c) Heat treatment state;
- d) Selected test method;
- e) Presentation of test results;
- f) This standard number.

6.2 In addition to the content specified in 6.1, the test report shall also include one of the following:

- a) When the microstructure testing method is selected, the test results shall at least include the etching method, the observation multiple, the percentage of the phase boundary area of the detrimental phase, at least one representative microstructure photo of the detrimental phase;
- b) When the Charpy impact test method is selected, the test results shall include the test temperature and the measured impact absorption energy value, as well as the judgement of test results according to the acceptance criteria specified in Table 3;
- c) When the ferric chloride corrosion test method is selected, the test results shall include the test temperature, the duration of the test, the weight loss of the test specimen and the corrosion rate (indicated by "mdd"). Determine whether the test result is qualified or not according to the corrosion rate measurement result according to the acceptance criteria as specified in Table 4. For unqualified specimens, the location of the corrosion area of the specimen (such as a certain surface, a certain edge or both) shall be recorded in detail, meanwhile other unforeseen corrosion behaviors shall be recorded.

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