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Spheroidal Graphite Iron Castings

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(ISO 1083:2018, Spheroidal Graphite Cast Irons - Classification, MOD)

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Spheroidal Graphite Iron Castings

1 Scope

This Standard specifies the designations, order information, manufacturing methods, chemical composition, technical requirements, sample preparation, test methods, inspection rules, marking, quality certificate, rust prevention, packaging and storage of spheroidal graphite iron castings.

This Standard is applicable to ordinary or low-alloy ferritic to pearlitic spheroidal graphite iron castings and solid solution strengthened ferritic spheroidal graphite iron castings cast in sand molds or casting molds with thermal conductivity equivalent to sand molds. Spheroidal graphite iron castings manufactured through special casting methods may also take this Standard as a reference.

This Standard is inapplicable to spheroidal graphite cast iron pipes, spheroidal graphite cast iron pipe fittings, parts and joints;

This Standard is inapplicable to Austenitic spheroidal graphite cast iron;

This Standard is inapplicable to Ausferrite spheroidal graphite cast iron (austempered spheroidal graphite cast iron).

2 Normative References

The following documents are indispensable to the application of this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 223.3 *Methods for Chemical Analysis of Iron, Steel and Alloy - The Diantipyryl Methane Phosphomolybdate Gravimetric Method for the Determination of Phosphorous Content*

GB/T 223.4 *Alloyed Steel - Determination of Manganese Content - Potentiometric or Visual Titration Method*

GB/T 223.60 *Methods for Chemical Analysis of Iron, Steel and Alloy - The Perchloric Acid Dehydration Gravimetric Method for the Determination of Silicon Content*

GB/T 223.72 *Iron, Steel and Alloy - Determination of Sulfur Content - Gravimetric Method*

GB/T 34904 *Spheroidal Graphite Iron Castings - Ultrasonic Testing*

3 Terms and Definitions

What is defined in GB/T 5611, and the following terms and definitions are applicable to this document.

3.1 Spheroidal Graphite Cast Iron

Spheroidal graphite cast iron refers to cast iron with iron, carbon and silicon as the basic elements, and with carbon mainly exists in the form of spheroidal graphite.

3.2 Ferritic to Pearlitic Spheroidal Graphite Cast Iron

Ferritic to pearlitic spheroidal graphite cast iron refers to spheroidal graphite cast iron which contains ferrite or pearlite, or a mixed matrix of ferrite and pearlite.

3.3 Graphite Spheroidizing Treatment

Spheroidizing Treatment

Graphite Spheroidizing treatment refers to a technological process, in which, spheroidizing agent is added to molten iron, so that carbon mainly precipitates in the form of spheroidal graphite during the solidification of the molten iron.

3.4 Relevant Wall Thickness

Relevant wall thickness refers to the section thickness of casting representing the mechanical properties of the casting materials.

3.5 Cast Sample

Cast sample refers to a test specimen representing the properties of the casting materials, including single-cast sample, side-by-side cast sample and attached cast sample.

3.6 Side-by-side Cast Sample

Side-by-side cast sample refers to a cast sample that uses the same casting system as the casting and is cast side by side with the casting.

3.7 Solid Solution Strengthened

Solid solution strengthened refers to the phenomenon that solute atoms dissolve into the metal matrix to form a solid solution, which increases the strength and hardness of the metal.

3.8 Solid Solution Strengthened Ferritic Spheroidal Graphite Cast Iron

a) Designation of casting materials;

b) Any special requirements (including the location of the relevant wall thickness) shall be negotiated and determined by the demand-side and the supply-side.

5.2 All order requirements shall be negotiated and determined by the demand-side and the supply-side at the same time that the order is accepted.

6 Manufacturing Methods and Chemical Composition

6.1 The manufacturing methods and chemical composition of spheroidal graphite cast iron shall be determined by the supply-side on its own. The chemical composition of spheroidal graphite cast iron shall not be used as the basis for the acceptance inspection of castings.

6.2 In terms of ferritic to pearlitic spheroidal graphite iron castings, the degree of the mechanical properties depends on the ratio of ferrite to pearlite. Generally speaking, the ratio of ferrite to pearlite is adjusted through the adjustment of the alloy content or the mode of thermal treatment.

6.3 The mechanical properties of solid solution strengthened ferritic spheroidal graphite cast iron depend on the degree of solid solution strengthening of the ferrite matrix. The degree of solid solution strengthening mainly depends on the silicon content. The chemical composition and physical properties of solid solution strengthened ferritic spheroidal graphite cast iron may take Appendix B as a reference.

7 Technical Requirements

7.1 General Rules

7.1.1 The performance index values listed in this Standard are the performance values of spheroidal graphite cast iron cast with sand molds or casting molds with thermal conductivity equivalent to sand molds. Upon agreement between the demand-side and the supply-side, it may also be used for spheroidal graphite cast iron cast by other methods.

7.1.2 The designation of casting materials is determined based on the minimum mechanical properties of a cast sample with a thickness or diameter of 25 mm. The designation is irrelevant to the type of the cast sample.

7.2 Ferritic to Pearlitic Spheroidal Graphite Cast Iron

7.2.1 Cast sample

7.2.1.1 Tensile properties

properties of the casting body test specimen shall take Appendix C as a reference.

NOTE 1: the property values of the casting body test specimen cannot be unified, because they depend on the complexity of the casting and the variation of the wall thickness.

NOTE 2: the mechanical property values of the casting body test specimen are affected by not only the material properties, but also the defects of the sampling location.

7.2.3 Classification by hardness

Upon agreement between the demand-side and the supply-side, classification may be conducted by hardness. Please take Appendix E as a reference.

7.2.4 Graphite morphology

7.2.4.1 Graphite is mainly in the form of Type-VI and Type-V. The spheroidizing level shall be not lower than Level-3 spheroidizing specified in GB/T 9441. More precise graphite morphologies and spheroidizing levels shall be negotiated and determined by the demand-side and the supply-side.

7.2.4.2 Graphite morphology may be determined through the method of observing metallographic specimens or non-destructive testing. When there are objections, the metallographic detection method shall prevail.

NOTE: Appendix F provides more reference documents regarding the spheroidization rate.

7.2.5 Matrix structure

Generally speaking, the requirements for matrix structure are determined by the supply-side. If there are special requirements, then, they shall be negotiated and determined by the supply-side and the demand-side. Table G.1 in Appendix G provides reference documents of matrix structures.

7.3 Solid Solution Strengthened Ferritic Spheroidal Graphite Cast Iron

7.3.1 Cast specimen

The tensile properties of cast specimen of solid solution strengthened ferritic spheroidal graphite cast iron shall comply with the stipulations of Table 3.

Upon agreement between the demand-side and the supply-side, classification may be conducted by hardness. Please take Appendix E as a reference.

7.3.4 Graphite morphology

7.3.4.1 Graphite is mainly in the form of Type-VI and Type-V. The spheroidizing level shall be not lower than Level-3 spheroidizing specified in GB/T 9441. More precise graphite morphologies and spheroidizing levels shall be negotiated and determined by the demand-side and the supply-side.

7.3.4.2 Graphite morphology may be determined through the method of observing metallographic specimens or non-destructive testing. When there are objections, the metallographic detection method shall prevail.

NOTE: Appendix F provides more reference documents regarding the spheroidization rate.

7.3.5 Matrix structure

The requirements for matrix structure are negotiated and determined by the demand-side and the supply-side. Table G.1 in Appendix G provides reference documents of the main matrix structures.

7.4 Geometric Shapes and Dimensional Tolerances

7.4.1 The geometric shapes and dimensions of the castings shall comply with the stipulations of the drawings.

7.4.2 The dimensional tolerances of the castings shall comply with the stipulations of GB/T 6414. When there are special requirements, comply with the drawings or relevant technical requirements.

7.5 Mass Tolerances

The mass tolerances of the castings shall comply with the relevant stipulations of GB/T 11351. When there are special requirements, comply with the drawings or relevant technical requirements.

7.6 Surface Quality of Casting

7.6.1 The castings shall be cleaned up; the excess parts shall be trimmed.

7.6.2 The requirements for the removal of casting riser residues, sticky sand, oxide scale and internal cavity residues shall comply with the technical specifications, or, the order agreement between the demand-side and the supply-side.

7.6.3 After using the plasma method to cut the castings, the heat affected zone shall be processed away.

9.6 Geometric Shapes and Dimensional Tolerances

9.6.1 The geometric shapes and dimensional tolerances of the castings shall be inspected in accordance with the requirements of 7.4.

9.6.2 For the first batch of castings, in accordance with the drawings, inspect the dimensions and geometric shapes of the castings piece by piece. Castings manufactured through methods that can ensure the dimensional stability may be spot-checked; the frequency and quantity of the spot-checks shall be negotiated and determined by the demand-side and the supply-side.

9.6.3 For castings in mass manufacturing, the frequency and quantity of the inspections shall be negotiated and determined by the demand-side and the supply-side.

9.7 Chemical Composition Analysis

9.7.1 When the demand-side has requirements for the chemical composition of the castings, they shall be implemented in accordance with the technical requirements of the demand-side. If there is no stipulation in the technical requirements of the demand-side, the chemical composition shall be determined by the supply-side on its own.

9.7.2 Spectrochemical analysis shall be performed in accordance with the stipulations of GB/T 24234.

9.7.3 The conventional chemical composition analysis methods of castings shall comply with the stipulations of GB/T 223.3, GB/T 223.4, GB/T 223.60, GB/T 223.72, GB/T 223.83 and GB/T 223.86.

9.8 Non-destructive Testing

9.8.1 Magnetic particle testing shall be conducted in accordance with the stipulations of GB/T 9444.

9.8.2 Penetrant testing shall be conducted in accordance with the stipulations of GB/T 9443.

9.8.3 Ultrasonic testing shall be conducted in accordance with the stipulations of GB/T 34904.

9.8.4 Radiographic testing shall be conducted in accordance with the stipulations of GB/T 5677.

9.9 Defects

9.9.1 The surface defects of the castings may be visually inspected. When the demand-side has special requirements, the method of magnetic particle testing or penetrant testing may also be used.

the manufacturing process combines the sampling batches and takes supporting measures in advance. During in-mold spheroidizing treatment, the size of the sampling batch and the test quantity shall be negotiated and determined by the demand-side and the supply-side when the order is accepted.

10.3 Re-inspection

10.3.1 Re-inspection conditions

If the result of the first inspection cannot satisfy the requirements for the mechanical properties of the materials, re-inspection is allowed.

10.3.2 Validity of inspection

10.3.2.1 When due to one of the following reasons, the inspection result does not satisfy the requirements, then, the inspection is invalid:

a) Improper loading of the test specimen on the testing machine, or, improper operation of the testing machine;

b) There are casting defects on the surface of the test specimen, or, improper machining of the test specimen (for example, non-conformant specimen size, transition fillet and roughness);

c) The tensile specimen breaks beyond the gauge length;

d) There are obvious casting defects on the fracture of the tensile specimen.

10.3.2.2 Under the above-mentioned circumstances, conduct re-sampling on the same cast sample, or, conduct re-sampling on the same casting batch of cast samples, then, conduct re-inspection. The result of the re-inspection shall replace the result of the invalid inspection.

10.3.2.3 The result of the re-inspection shall be considered as the final inspection result.

10.4 Evaluation of Inspection Result

10.4.1 During the inspection of mechanical properties, firstly, use one tensile specimen for the inspection. If it complies with the requirements, then, the batch of castings is qualified in terms of texture; if the inspection result fails to comply with the requirements, and the failure is not caused by reasons listed in 10.3.2.1, then, take another two specimens from the same batch of specimens for the re-inspection.

10.4.2 During the impact test, if the impact absorption energy of three impact specimens complies with the requirements, then, the batch of castings is qualified in terms of impact performance; if the test result of one specimen fails to reach the minimum value, then, double-take three spare impact specimens from the same batch for the test; add the result to the original result, so as to re-calculate the average value.

strength, yield strength, elongation and Brinell hardness of each test specimen. When the demand-side and the supply-side obtain the desired statistical confidence, corresponding to each Brinell hardness value, in order to obtain a minimum tensile strength, multiple tests may be performed.

e) Draw a histogram of the property of tensile strength as one of the functions of hardness.

f) For each Brinell hardness value, select the corresponding minimum tensile strength value as the index of the process capability.

g) List one-by-one the minimum hardness value of each designation of material that satisfies the tensile strength and yield strength value in Table 1 and Table 3.

h) List one-by-one the maximum hardness value of each designation of material that satisfies the elongation value in Table 1 and Table 3.

The hardness ranges of the maximum and minimum Brinell hardness values shall be determined in accordance with the above procedures.

E.4 Requirements for Sampling

Each hardness test may be performed on a test bar, or, a position on the casting body agreed by the demand-side and the supply-side. When there is no agreement between the demand-side and the supply-side, the supply-side may choose to conduct sampling in a representative position on the casting.

E.5 Test Methods

E.5.1 The test method for hardness shall comply with the stipulations of GB/T 231.1.

E.5.2 If it is impossible to test the hardness on the casting body, through the negotiation and determination between the demand-side and the supply-side, the hardness may also be tested on attached cast sample or single-cast sample.

E.5.3 If the casting requires thermal treatment, the attached cast bar (sample) shall be cut after the casting receives the thermal treatment.

E.5.4 If a test specimen is cut from a single-cast sample for the hardness test, when the casting has any requirements for thermal treatment, the cast sample shall receive the thermal treatment together with the casting that it represents.

E.6 Frequency and Quantity of Hardness Tests

The frequency and quantity of hardness tests shall be determined by the demand-side and the supply-side through negotiation.

Appendix F

(informative)

Spheroidization Rate (or spheroidal graphite ratio)

The spheroidization rate of spheroidal graphite cast iron is defined as the percentage of spheroidal graphite and nodular graphite. The spheroidization rate may be determined by the following three methods:

---Comparing with the schematic diagram of graphite particle morphology in GB/T 9441, estimate the percentage of Type-V and Type-VI graphite spheres.

---Under a metallographic microscope, adopt the method of visual observation to compare the mapping of graphite morphology of spheroidal graphite cast iron.

---Through automatic image analysis, determine the percentage of the area of Type-V and Type-VI graphite in the area of all graphite particles.

This percentage is usually obtained by cutting the test specimen on the cross-section, and then, polishing it and observing it at 100 times; it may also be obtained by image analysis at a relatively high magnification; it may also be obtained after pre-calibration by measuring the speed of ultrasonic sound passing through the material.

The spheroidization degree depends on not only the manufacturing processing (charge, residual magnesium and inoculation mode, etc.), but also the cooling modulus of the casting section. In addition, some deteriorated graphite is related to the mold.

Even for materials with a given cooling modulus, it is impossible to accurately determine the minimum characteristic value that generates the critical spheroidization degree. That is because the variation of the spheroidization degree is related to not only the used determination method, but also the material designation (especially the chemical composition of the material) of the casting and the amount of graphite per unit area.

However, 80% ~ 85% or higher spheroidization rate can usually guarantee the minimum tensile property value specified in the Standard (a higher yield strength $R_{P0.2}$). Most of 15% ~ 20% graphite is not spheroidal or nodular, but temper graphite, and some might be vermicular graphite.

The castings need to withstand a variety of loads, especially that a higher spheroidization rate (including the percentage of spheroidal and nodular graphite) is required in the fatigue state. For special castings and material designations, the requirement for a higher spheroidization rate shall be evaluated through experimental research.

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