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Cast Grinding Balls

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Cast Grinding Balls

1 Scope

This Document specifies the designations and codes, technical requirements, test methods, inspection rules, markings, certificates, packaging and transportation of chromium alloy white cast iron grinding balls and ductile iron grinding balls for drum mills.

This Document is applicable to chromium alloy white cast iron grinding balls and ductile iron grinding balls (hereinafter referred to as "grinding balls") used for crushing and grinding ore, coal, cement and other related materials in the metallurgical, electric power, building materials and chemical industries.

2 Normative References

The provisions in following documents become the essential provisions of this Document through reference in 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 223.3 Methods for chemical analysis of iron, steel and alloy; The diantipyrylmethane phosphomolybdate gravimetric method for the determination of phosphorus content

GB/T 223.4 Alloyed steel - Determination of manganese content - Potentiometric or visual titration method

GB/T 223.11 Iron, Steel and Alloy - Determination of Chromium Content - Visual Titration or Potentiometric Titration Method

GB/T 223.18 Methods for Chemical Analysis of Iron, Steel and Alloy - The Sodium Thiosulfate Separation Iodometric Method for the Determination of Copper Content

GB/T 223.23 Iron, Steel and Alloy-Determination of Nickel Content - The Dimethylglyoxime Spectrophotometric Method

GB/T 223.26 Iron, Steel and Alloy - Determination of Molybdenum Content - The Thiocyanate Spectrophotometric 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 223.63 Methods for chemical analysis of iron, steel and alloy - The sodium (potassium) periodate photometric method for the determination of manganese content

GB/T 223.71 Methods for Chemical Analysis of Iron, Steel and Alloy - The Gravimetric Method after Combustion in the Pipe Furnace for the Determination of Carbon Content

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

GB/T 230.1 Metallic materials - Rockwell hardness test - Part 1:Test method

GB/T 5611 Foundry terminology

GB/T 5612 Code for representing cast iron

GB/T 8170 Rules of rounding off for numerical values & expression and judgment of limiting values

GB/T 9441-2009 Metallographic test for spheroidal graphite cast iron

GB/T 20066 Steel and Iron - Sampling and Preparation of Samples for the Determination of Chemical Composition

GB/T 24234 Cast iron - Determination of multi-element contents - Spark discharge atomic emission spectrometric method (Routine method)

3 Terms and Definitions

For the purposes of this Document, the following terms and definitions given in GB/T 5611 apply.

3.1 Chromium alloy white cast iron grinding ball

Grinding balls that are cast from white cast iron with chromium as the main alloying element.

3.2 Ductile iron grinding ball

Grinding balls that are made of ductile iron.

3.3 Breakage ratio of ball

The percentage of the total weight of broken balls to the total weight of used balls.

NOTE: Broken balls refer to grinding balls whose broken area exceeds 1/3 of the surface area of the grinding balls during normal production operation of the mill.

3.4 Impact fatigue life of grinding ball

The number of impacts that a grinding ball sustains, when it fails due to impact fatigue, measured in a drop ball test.

5.3.4 Whether the Impact fatigue life of grinding ball and ball consumption are used as acceptance items shall be agreed upon by the supplier and the purchaser.

5.4 Surface quality

Grinding balls should not have cracks and casting defects such as slag inclusions, sand holes, shrinkage cavities, shrinkage, pores, cold shuts, etc. that affect the performance.

5.5 Metallographic structure

5.5.1 The metallographic structure of chromium alloy white cast iron grinding balls and ductile iron grinding balls is not used as an acceptance item for products. If there are special needs, it shall be agreed upon by the supplier and the purchaser.

5.5.2 The graphite spheroidization level of ductile iron grinding balls shall be no lower than Level-3 specified in GB/T 9441-2009. The number of graphite balls shall be no less than 100 piece/mm^2. If there are special requirements, the spheroidization level shall be agreed upon by the supplier and the purchaser. Other metallographic structures are not accepted as acceptance items of the product. If there are special needs, they shall be agreed upon by the supplier and the purchaser.

6 Test Method

6.1 The diameter of the grinding balls shall be measured with a measuring tool with an accuracy of no less than 0.1mm.

6.2 The chemical composition analysis method shall be carried out in accordance with the provisions of GB/T 223.3, GB/T 223.4, GB/T 223.11, GB/T 223.18, GB/T 223.23, GB/T 223.26, GB/T 223.60, GB/T 223.63, GB/T 223.71 and GB/T 223.72.

6.3 The preparation and sampling methods of specimens for chemical composition analysis shall comply with the provisions of GB/T 20066. The preparation and sampling of spectral analysis specimens shall comply with the provisions of GB/T 24234.

6.4 The Rockwell hardness test shall be carried out in accordance with the provisions of GB/T 230.1. The surface hardness is allowed to be tested with a portable hardness tester.

6.5 The surface hardness shall be tested 2mm~3mm below the surface of the grinding ball. The hardness test surface shall be machined, wire cut or electrospark machined; and the wire cut or electrospark machined surface shall be machined to remove the heat affected zone.

6.6 Conduct impact fatigue test of grinding ball according to Appendix A.

6.7 The determination and calculation of breakage ratio of ball shall comply with the provisions of Appendix B.

6.8 The calculation of ball consumption shall comply with the provisions of Appendix C.

7 Inspection Rules

7.1 Inspection batch

One of the following situations constitutes an inspection batch:

a) Chemical composition inspection batch: when electric furnace smelting is adopted, each furnace is regarded as a batch; when cupola furnace smelting is adopted, every 2 h is regarded as a batch;

b) Grinding ball diameter and hardness inspection batch: grinding balls of the same designation cast in multiple furnaces under the condition of stable smelting process and subjected to the same heat treatment process (if heat treatment is required), heat-treated in intermittent heat treatment furnace, with the same nominal diameter in each furnace are regarded as a batch; grinding balls heat-treated in continuous heat treatment furnace, with the same nominal diameter every 10t are regarded as a batch.

7.2 Judgment rules

7.2.1 Take one specimen from each batch for chemical composition inspection. When sampling by taking chips, chips at least 6mm below the casting surface shall be removed. If the inspection result is unqualified, double sampling can be carried out for reinspection. If one specimen is still unqualified, the chemical composition of the batch of grinding balls shall be judged as unqualified.

7.2.2 Three grinding balls are randomly selected from each batch for inspection of diameter and hardness. If the diameter or hardness of one grinding ball fails to meet the standards, the same number of grinding balls are randomly selected for reinspection. If the number of grinding balls that fail to meet the standards in the two inspections is greater than or equal to 2, the diameter or hardness of the batch of grinding balls shall be determined to be unqualified. If the diameter or hardness of two grinding balls fails to meet the standards in the first sampling, the diameter or hardness of the batch of grinding balls shall be determined to be unqualified. If the hardness of the grinding balls fails to meet the standards, re-heat treatment shall be allowed.

7.2.3 The inspection results of chemical composition, hardness and diameter shall be rounded off in accordance with the provisions of GB/T 8170.

Appendix A

(Normative)

Test Method of Impact Fatigue Life of Grinding Ball

A.1 Test principle

The impact fatigue life test of grinding ball of ball drop method (hereinafter referred to as the "ball drop test") uses a ball to drop on the fatigue test machine (hereinafter referred to as the "ball drop test machine") to simulate the impact process of cast grinding balls in a drum mill under laboratory conditions; calculate the number of impacts of the cast grinding balls when they fail due to impact fatigue; and use the number of impacts when fatigue failure occurs to represent the impact fatigue life of the cast grinding balls.

The number of impacts is displayed by a counter; and the impact fatigue life of the cast grinding balls shall be no less than 8000 times.

A.2 Ball drop machine model

The ball drop machine model is Type-MQ, and the drop distance is 3.5m.

A.3 Specimen

The specimen for the ball drop test is a ϕ100mm grinding ball.

A.4 Number of grinding balls for the ball drop test

The specimen for the ball drop test shall be 16 cast grinding balls randomly selected from the batch to be inspected as test balls; and 3 or more cast grinding balls shall be selected as replacement balls; and marks shall be placed on the surface of the replacement balls.

A.5 Ball drop test temperature

The ball drop test is carried out at room temperature.

A.6 Judgment and test procedure of cast grinding balls failure

A.6.1 Test procedure

A.6.1.1 Grind the edges of the test balls and replacement balls or clean the surfaces in the cleaning drum; and check the working status of the test machine.

A.6.1.2 First put 12 test balls into the curved pipe; start the test machine; and gradually put the

remaining 4 test balls into the circulation conveying system from the downhill slide.

A.6.1.3 Turn on the counter; reset the counter; clear the alarm; and turn the digital dial to the preset number (8000).

A.6.1.4 The test personnel shall observe carefully on site. When it is found that one test ball fails in accordance with the provisions of a) or b) in A.6.2, take out the failed ball and put in a replacement ball until the third failed ball appears; and respectively record the cumulative number of impacts received by the three test balls in the ball drop machine system when they fail. If the number of failed balls in the test does not reach the indicator number of failed ball, the added replacement ball has been damaged and then it shall not be counted in the number of failed balls.

A.6.2 Failure judgment

When one of the following situations occurs, the cast grinding ball can be judged as failed:

a) The average diameter of the peeling layer on the surface of the cast grinding ball (the average of the maximum and the minimum diameter) is greater than 20mm; and meanwhile the thickness in the middle is greater than 5mm;

b) The cast grinding ball is broken along the middle.

A.7 Impact fatigue test life of grinding ball

The impact fatigue test life of grinding ball is determined according to Formula (A.1):

$$N_f = \frac{2B_t}{B_s} \times \frac{N_1 + N_2 + N_3}{3} \qquad \text{(A.1)}$$

Where:

N_f – Impact fatigue test life (number of times) of this batch of grinding balls;

B_t – The number of cast grinding balls in the curved pipe;

B_s – The total number of cast grinding balls in the test system;

N_1 – The number of times recorded by the counter when the first test ball fails;

N_2 – The number of times recorded by the counter when the second test ball fails;

N_3 – The number of times recorded by the counter when the third test ball fails.

A.8 Data processing

When processing data, the decimal part shall be filled in the test report with integer value according to the numerical rounding rules of GB/T 8170.

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