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Test method for electrochemical properties of magnesium alloys sacrificial anode

镁合金牺牲阳极电化学性能测试方法

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Test method for electrochemical properties of magnesium alloys sacrificial anode

Warning -- This document does not indicate all possible safety issues. The user of this document shall take appropriate safety and health measures and formulate corresponding rules and regulations.

1 Scope

This document specifies the electrochemical performance test method for magnesium alloy sacrificial anode samples when working in saturated calcium sulfate and magnesium hydroxide medium.

This document applies to the electrochemical performance test for magnesium alloy sacrificial anodes (hereinafter referred to as buried anodes) when the saturated calcium sulfate and the magnesium hydroxide testing electrolyte are used for serving as the padding for the buried anode. This document can also be used as a reference for the electrochemical performance test of the magnesium alloy sacrificial anode for a water heater (hereinafter referred to as water-heater anode) used in freshwater.

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 6682 Water for analytical laboratory use—Specification and test methods

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

GB/T 17731 Magnesium alloy sacrificial anode

3 Terms and Definitions

The terms and definitions defined in GB/T 17731 and the following apply to this document.

3.1 Closed circuit potential

In the electrolyte, the cathode is connected to the sacrificial anode; the potential of the sacrificial anode that is relative to the reference electrode, when the current is passing through.

3.2 Open circuit potential

In the electrolyte, the cathode is connected to the sacrificial anode; the potential of the sacrificial anode that is relative to the reference electrode, after the current is disconnected for 1 h.

3.3 Practical current capacity

The actually measured amount of electricity produced by consuming a unit mass of sacrificial anode.

[Source: GB/T 17731-2015, 3.1]

3.4 Theoretical current capacity

The amount of electricity produced by consuming a unit mass of sacrificial anode, which is calculated according to Faraday's law.

[Source: GB/T 17731-2015, 3.2]

3.5 Current efficiency

The percentages of practical current capacity and theoretical current capacity.

4 Principle of the method

Make the constant DC current flow through a series-connected test cell consisting of a pre-weighed magnesium alloy anode sample, a steel cathode test crucible, and the electrolyte for 14 d. Measure the oxidation potential of the sample several times during the test; measure the oxidation potential of the sample after the test ends and the current is disconnected for 1 h; measure the total amount of electricity flowing through the battery. After the test, wash and weigh each sample, and calculate the amount of electricity obtained from the loss of a unit mass of the sample.

5 Test conditions

During the test, the temperature of the electrolyte shall be kept within the range of 22 °C±5 °C.

9 Test steps

9.1 Test preparation

9.1.1 When using a copper coulombmeter (as shown in Figure 2), use fine abrasives (00 # or finer) to grind the coulombmeter's cathode copper wire; then, put it in an oven, dry it at 105 °C for 15 minutes, and cool it to room temperature; weigh it, and the weight shall be accurate to 0.1 mg. The anode copper sheet shall be cleaned before being put in the coulombmeter's solution, and the purity of copper wire and copper sheet shall not be less than 99.9%.

9.1.2 Wash the anode sample with water and acetone in turn; then, put it in an oven, dry it at 105 °C for 30 min, and cool it to room temperature; weigh it, and the weight shall be accurate to 0.1 mg. After the sample is cleaned with acetone, in order to avoid contamination of the sample, the sample shall be handled with gloves.

9.1.3 Buried anode sample: Use insulating tape to wrap the surface between 100 mm and 139 mm from the immersed end face of the sample, so that the immersion area of the sample is 41.2 cm^2.

9.1.4 Sample of the extruded magnesium anode of the water heater: Seal the immersed end face and the surface 10 mm away from it with insulating materials; wrap the surface between 113.2 mm and 142 mm from the immersed end face of the sample with insulating tape, so that the immersed area of the sample is 41.2 cm^2.

9.1.5 Sample of the cast magnesium anode of the water heater: Process it according to the method of "9.1.3 Buried anode sample".

9.1.6 Brush the cathode test crucible with soft plastic. If the inner surface of the cathode test crucible is completely covered by a high-resistance coating, and the required current cannot be obtained, the high-resistance coating on the surface shall be removed by sandblasting, wire brushing, or scraping.

9.2 Sample determination

9.2.1 Add the electrolyte to the cathode test crucible until the solution is about 15 mm away from the top.

9.2.2 Insert the sample into the rubber stopper and then put it in the cathode test crucible.

9.2.3 Put the anode copper sheet and cathode copper wire in the coulombmeter's solution, and the length of the copper wire immersed shall be 10 mm~50 mm.

9.2.4 The schematic diagram of the complete test circuit is shown in Figure 6. 0.75 mm^2 insulated stranded copper wire is used in the circuit. Each end of each wire is connected

method of the closed-circuit potential in 9.2.6.

9.2.8 After the test is completed, first remove the wires on the sample; then, take the sample out of the electrolyte, and remove the rubber stopper; finally, remove the tape on the sample.

9.2.9 Put an untested sample in the cleaning solution preheated to 60 °C~80 °C, leave it in the solution for 10 minutes (or put it in the cleaning solution at room temperature for 30 minutes); then, wash it with tap water, and finally dry it in a 105 °C oven for 30 min; if the mass loss of the sample is greater than 5 mg, pour out the cleaning solution; if the mass loss of the sample is less than 5 mg, place the tested sample and the untested sample together in the cleaning solution at 60 °C~80 °C for 10 min or put them in room temperature cleaning solution for 30 min; then, wash them with tap water, and dry them in a 105 °C oven for 3 h; if the mass loss of the untested sample is more than 5 mg, repeat the steps 9.2.1~9.2.9.

9.2.10 When using a copper coulombmeter, the cathode copper wire on the coulombmeter shall be removed, then washed with tap water, and finally placed in an oven and dried at 105 °C for 30 minutes.

9.2.11 Take the sample, untested sample, and copper coulombmeter's cathode copper wire out of the oven, and cool them to room temperature; weigh them, and the weights shall be accurate to 0.1 mg.

To avoid contamination of the sample and the coulombmeter's cathode copper wire, gloves shall be worn during the weighing process.

10 Experimental data processing

10.1 To calculate the electric quantity Q_1(A • h) flowing through the test battery during the 14-d test. When using a copper coulombmeter, calculate the electric quantity Q_1 according to formula (1). When using an electronic coulombmeter, calculate the electric quantity Q_1 according to formula (2).

$$Q_1 = 0.843\ 3(m_2 - m_1) \qquad \cdots\cdots(1)$$

Where:

0.8433 --- Theoretical capacitance of copper, in ampere-hour per gram (A • h/g);

m_2 --- The final mass of the copper coulombmeter's cathode wire, in grams (g);

m_1 --- The initial mass of the copper coulombmeter's cathode wire, in grams (g).

11 Precision

11.1 Repeatability

In the same laboratory, according to the same test method, the same operator uses the same equipment to test the same object in a short period. The absolute differences between the two independent test results (the average value of 5 samples) obtained by conducting tests independently shall not be greater than the following values; it is premised that the situation that the absolute differences are more than the following values does not exceed 5%.

--- Actual capacitance: ≤0.06 A • h/g.

--- Final closed-circuit potential: ≤0.01 V.

--- Open-circuit potential: ≤0.02 V.

11.2 Reproducibility

In different laboratories, according to the same test method, different operators use different equipment to test the same object independently. The absolute differences between the two independent test results (the average value of 5 samples) obtained by conducting the test independently shall not be greater than the following values; it is premised that the situation that the absolute differences are more than the following values does not exceed 5%.

--- Actual capacitance: ≤0.15 A • h/g.

--- Final closed-circuit potential: ≤0.05 V.

--- Open-circuit potential: ≤0.08 V.

12 Test report

The test report shall include but not be limited to the following aspects:

--- Test object;

--- Number of this document;

--- Test data (including potential, capacitance, current efficiency);

--- Temperature of electrolyte;

--- Observed anomalies;

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