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Replacing GB/T 6519-2013

Ultrasonic inspection of wrought aluminium and magnesium alloy products

变形铝、镁合金产品超声波检验方法

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Foreword

This document was drafted in accordance with the provisions of GB/T 1.1-2020 "Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents".

This document replaces GB/T 6519-2013 "Ultrasonic inspection of wrought aluminium and magnesium alloy products". Compared with GB/T 6519-2013, in addition to structural adjustments and editorial changes, the main technical changes are as follows:

a) CHANGE the method overview, indicating the factors affecting the flaw detection results (see Chapter 4; Chapter 4 of the 2013 edition);

b) CHANGE the requirements for inspectors (see 5.1; Chapter 5 of the 2013 edition);

c) CHANGE the inspection environment requirements, clarifying the inspection temperature (see 5.2; Chapter 6 of the 2013 edition);

d) CHANGE the materials, detailing the requirements for standard test blocks and comparison test blocks (see Chapter 6; 7.1 of the 2013 edition);

e) ADD the requirements for dynamic test reference specimens (see 6.1.3);

f) CHANGE the probe (see 7.1; 7.2 of the 2013 edition);

g) CHANGE the ultrasonic testing instrument (see 7.2; 7.3 of the 2013 edition);

h) ADD the test mode and test method (see 9.1);

i) ADD the testing reliability verification requirements for special types of defects (see 9.7);

j) ADD the dynamic scanning verification requirements (see 9.8);

k) CHANGE the quality acceptance level, adding the assessment requirements for intensive defects (see 9.10; 9.2.7.2 of the 2013 edition);

l) ADD the post-test processing of samples and test marking (see 9.11);

m) ADD the quality assurance and control (see Chapter 11).

Please note that some of the contents of this document may involve patents. The issuing agency of this document does not assume the responsibility for identifying patents.

This document was proposed by the China Nonferrous Metals Industry Association.

This document shall be under the jurisdiction of the National Technical Committee for

Ultrasonic inspection of wrought aluminium and magnesium alloy products

1 Scope

This document describes the ultrasonic inspection method for wrought aluminum and aluminum alloys, wrought magnesium and magnesium alloy products.

This document is applicable to ultrasonic inspection of wrought aluminum and aluminum alloys, wrought magnesium and magnesium alloy products, using ultrasonic pulse reflection technology.

This document is not applicable to ultrasonic inspection of castings, welded parts, layered composites, which are produced by aluminum, magnesium and their alloys.

2 Normative references

The contents of the following documents constitute the essential terms of this document through normative references in the text. Among them, for dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 12604.1 Non-destructive testing - Terminology - Ultrasonic testing

GB/T 18694 Non-destructive testing - Ultrasonic inspection - Characterization of search unit and sound field

GB/T 18852 Non-destructive testing - Ultrasonic testing - Reference blocks and test procedures for the characterization of contact probe sound beams

GB/T 19799.1 Non-destructive testing - Ultrasonic testing - Specification for calibration block No.1

GB/T 28880 Non-destructive testing - Evaluating performance characteristics of ultrasonic pulse-echo testing systems without the use of electronic measurement instruments

JJG 746 Verification regulation for ultrasonic flaw detectors

YS/T 874 Ultrasonic inspection of wrought aluminium alloy columniform ingots by the water immersion method

YS/T 1187 Ultrasonic inspection of aluminium and aluminium alloy thin-walled tubing

YS/T 1188 Ultrasonic inspection of wrought aluminium alloy ingots

YS/T 1633 Ultrasonic phased array inspection method for deformed aluminum and aluminum alloy products

3 Terms and definitions

The terms and definitions, which are defined in GB/T 12604.1, apply to this document.

4 Method overview

The piezoelectric crystal in the probe generates ultrasonic waves under the stimulation of electric pulses. The ultrasonic waves propagate in the sample under test through the coupling medium. If they encounter defects (heterogeneous interfaces), they will generate reflected waves and refracted waves, which will be received by the probe. The piezoelectric crystal in the probe converts the ultrasonic waves into electrical signals, which are received by the instrument for signal processing, amplification, display. The displayed information is compared with the ultrasonic response signal of the known ultrasonic reference reflector specified in the acceptance standard; the value and position of the detected defects are evaluated, to assess the quality of the sample under test.

Note 1: Due to the surface state, geometric shape, inclination of the ultrasonic beam perpendicular to the incident surface of the sample under test, the amplitude of the defect and the bottom reflection wave may be reduced. These factors will seriously reduce the reliability of the test results of the ultrasonic inspection method specified in this document.

Note 2: The assessment of the defect equivalent value is affected by factors such as the characteristics of the probe, the surface state of the defect, the nature and shape of the defect. The comparison and assessment of the ultrasonic inspection defect test data specified in this document with the data of the recognized ultrasonic reference reflector test is carried out under restricted conditions; it is difficult to determine the actual size of the defect detected in the sample under test.

Note 3: Because there are many variables in the inspection system that affect the results of ultrasonic inspection, it is difficult to determine the actual quantitative impact of the detected defects on the mechanical properties of the inspected samples. Although this method provides a reliable method for quality control in product manufacturing, it is inappropriate to use it as a special indication of the final performance and quality of the product processing workpiece inspected in this document.

5 Inspection conditions

5.1 Inspectors

5.1.1 Ultrasonic inspectors shall pass the training and examination of the nationally recognized or customer-recognized non-destructive testing professional certification body; obtain the corresponding level of qualification certificate.

5.1.2 Ultrasonic inspectors shall perform ultrasonic inspection work, in accordance with the technical level of their qualification certificates.

5.1.3 Ultrasonic inspectors shall also receive training on the operation of this document, inspection procedures, inspection equipment before taking up their posts. They may only take up their posts after passing the examination and obtaining approval from the enterprise's top management or its authorized representative.

5.2 Inspection environment

5.2.1 The inspection environment temperature should be kept within the range of 22 °C ± 15 °C; the sample temperature shall be the same as the ambient temperature.

5.2.2 The inspection environment shall not have strong magnetism, vibration, high frequency, large dust, large mechanical noise, corrosive gas.

5.2.3 The inspection site shall be safe, with sufficient space and appropriate light, to ensure the validity of the inspection results.

6 Materials

6.1 Standard test blocks, comparison test blocks, dynamic test reference specimens

6.1.1 Standard test blocks shall comply with the provisions of Appendix A.

6.1.2 Comparison test blocks shall comply with the provisions of Appendix B.

6.1.3 Dynamic test reference specimens shall comply with the provisions of Appendix C.

6.2 Coupling agent

The coupling agent shall comply with the provisions of Table 1. The same coupling agent shall be used for benchmark sensitivity adjustment, sample inspection, defect assessment.

according to the provisions of 7.1.2.2.

7.1.2.1.2 When the contact method test uses a circular straight probe and the immersion method test uses a circular flat probe, the ratio -- of the minimum value to the maximum value of the effective sound beam -- as measured at the last sound pressure maximum of the probe shall be greater than 0.75; there shall be no obvious side lobes during the test.

7.1.2.1.3 When using a shear wave probe, it shall test the sound incident point, front edge distance, refraction angle. When the refraction angle deviates from the nominal value by more than 2°, the probe angle shall be corrected before use.

7.1.2.1.4 When using a focusing probe, it shall test the focal length, focal column length, focal size in water.

7.1.2.1.5 When using a brush probe, adjust the test parameters under the working water distance setting, so that the ultrasonic response amplitude of the flat-bottom hole of the acceptance level is 50% of the vertical limit. Test the sensitivity consistency along the long side of the probe within the effective sound beam range. The change of the ultrasonic response amplitude of the flat-bottom hole shall be within the range of 40% ~ 60% of the vertical limit. Make a test ultrasonic response amplitude distribution diagram, to determine the lowest sensitive area of the probe.

7.1.2.1.6 When the probe is used for the first time, the peak frequency of the probe shall be tested. The peak frequency deviation of the probe is ±10% of the nominal frequency.

7.1.2.1.7 The distance-gain ultrasonic response curve of the probe shall be made according to the provisions of 7.1.2.3. The signal-to-noise ratio shall be greater than 2:1.

7.1.2.1.8 The test data shall be compared with the initial test data. The deviation of the distance-gain ultrasonic response curve, when using the contact method test probe, shall not be greater than 6 dB; the deviation of the distance-gain ultrasonic response curve, when using the immersion method test probe, shall not be greater than 2 dB.

7.1.2.1.9 Phased array probes shall comply with the provisions of YS/T 1633.

7.1.2.2 Test effective sound beam

7.1.2.2.1 In a group of flat bottom hole comparison test blocks with the same hole diameter, hole depth but different burial depth, at least select the comparison test blocks with flat bottom hole burial depths of 1/4, 2/4, 3/4 of the inspection range, the upper surface resolution, as well as the last sound pressure maximum value for effective sound beam test. The flat bottom hole diameter is the minimum size required by the acceptance level. For the immersion test probe, the effective sound beam of the probe can be tested with a steel ball.

7.1.2.2.2 Move the probe to the top of the flat bottom hole of the comparison test block.

Move the probe to find the maximum ultrasonic response amplitude of the flat bottom hole. Adjust the instrument gain, so that the amplitude is 80% of the vertical limit. At this position, move the probe forward and backward or left and right respectively, until the ultrasonic response amplitude drops to 40% of the vertical limit. Move the probe in the opposite direction to be beyond the maximum ultrasonic response, until the ultrasonic response amplitude drops to 40% of the vertical limit again. Measure the distance between the two center positions of the probe, which is the effective sound beam size of the probe.

7.1.2.2.3 The circular probe shall be tested for effective sound beams in two vertical directions; the dual crystal probe shall be tested for effective sound beams in the direction parallel to the sound insulation layer; the brush probe shall be tested for effective sound beams in the direction parallel to the long side.

7.1.2.2.4 When using a multi-channel ultrasonic system for inspection, all probes shall be tested for effective sound beams.

7.1.2.2.5 When the instrument is replaced or repaired, or when the water path distance of the water immersion test probe changes, the effective sound beam test shall be re-performed.

7.1.2.3 Make a distance-gain ultrasonic response curve

7.1.2.3.1 Place the longitudinal wave probe above the flat bottom hole of the comparison test block. Move the probe, to find the maximum ultrasonic response amplitude of the flat bottom hole. Adjust the instrument gain, so that the amplitude is 80% of the vertical limit. Record the gain value at this time. Use the same method to test each flat bottom hole with different burial depths. Draw a distance-gain ultrasonic response curve. For the brush probe, determine the probe's lowest sensitivity area based on the ultrasonic response amplitude distribution diagram of the test. Make a distance-gain ultrasonic response curve.

7.1.2.3.2 Place the shear wave probe on the test surface of the comparison test block. Move the probe to find the maximum ultrasonic response amplitude of the ultrasonic reference reflector. Adjust the instrument gain, so that the amplitude is 80% of the vertical limit. Record the gain value at this time. Use the same method to test each ultrasonic reference reflector with different burial depths. Make a distance-gain ultrasonic response curve.

7.1.3 Probe quality certificate and identification

7.1.3.1 The exit-factory quality certificate of conventional probes shall comply with the provisions of GB/T 18694 and GB/T 18852 and meet the procurement requirements. The quality certificate of phased array probes shall comply with the provisions of YS/T 1633 and meet the procurement requirements.

7.2.2 The ultrasonic phased array tester shall comply with the provisions of YS/T 1633.

7.2.3 The ultrasonic tester shall be calibrated annually or before the first use or after the parts are overhauled and replaced and shall comply with the provisions of 7.2.1.

7.2.4 The power supply of the ultrasonic tester shall be stable. When the signal amplitude of the ultrasonic tester is adjusted to 50% of the vertical limit, the change of the signal amplitude of the ultrasonic tester caused by voltage fluctuation shall be within the range of 47.5% ~ 52.5% of the vertical limit. When the signal amplitude fluctuation exceeds this range, a voltage stabilizer shall be added or the battery shall be replaced.

7.2.5 All equipment used to evaluate the ultrasonic tester shall be traceable.

7.2.6 When the purchaser has special requirements for product inspection, the minimum performance indicators and test methods of the instrument shall be determined by negotiation between the supplier and the buyer.

7.3 Auxiliary devices

7.3.1 Auxiliary devices for automatic water immersion inspection

The auxiliary devices for automatic water immersion inspection shall enable the sound energy to be effectively transmitted into the inspected sample, have strong anti-interference ability, convenient operation, safe use, stable and reliable operation, at least including a water tank or probe and inspected sample sound transmission coupling device, an automatic inspection transmission device, a probe manipulator, a probe reference control device, etc. The specific requirements are as follows:

- In the automatic scanning of longitudinal wave vertical incidence, the probe can always keep the sound beam vertically incident on the inspection surface;

- The mechanical movement accuracy of the probe manipulator shall be calibrated at least once a year;

- The water tank or water supply device shall be able to immerse the inspected part of the sample, so that the water distance meets the inspection requirements, meanwhile the probe shall have enough space for smooth movement;

- The automatic water immersion inspection transmission device shall enable the probe to move smoothly within the inspection range; the steering gear shall be able to accurately adjust the probe angle; the bridge shall have sufficient strength to provide rigid support for the manipulator and the probe steering device, meanwhile it can smoothly and accurately position the probe at the required position;

- The probe steering device shall be able to provide probe angle adjustment within two mutually perpendicular planes, which have an error of no more than ±0.5°. The scanning step and positioning deviation of the scanning device shall not exceed 2.5

mm; the water distance shall be adjustable;

- If the size or geometry of the sample under test cannot use the steering device, there shall be a probe reference control device to control the water distance and the sound beam angle. Whether the sample under test or the probe moves, the water distance and the direction of incidence of the sound beam shall not change during the inspection;

- When the special probe support fixture can meet the specified requirements of the manipulator and bridge, meanwhile it can obtain test results equivalent to those of the probe manipulator, these special probe fixtures can be used.

7.3.2 Water immersion manual auxiliary device

If the clamp of the water immersion manual manipulator probe is used, the water distance and the incident angle of the probe sound beam shall be controlled, to ensure that the probe and the sample under test maintain a certain water distance. The probe angle shall be unchanged and the water distance shall be stable during the inspection.

7.3.3 Auxiliary device for contact method

During contact method inspection, the probe is usually placed on the inspection surface of the sample to be inspected. When a special fixture can ensure the validity of the inspection results, a special fixture can be used.

8 Sample

8.1 Inspection surface

8.1.1 The inspection surface of the sample shall be determined through negotiation by the supplier and the buyer, based on the processing deformation characteristics, defect distribution law, defect characteristics, use requirements of the sample; it shall be indicated in the drawings, order forms (or contracts). For forgings and profiles, it shall also indicate the processing allowance.

8.1.2 If not specified in the drawing, order (or contract), the inspection surface shall be determined, so that the central axis of the sound beam is perpendicular to the main plane of the defect. The sound beam of forgings, extrusions, rolled parts, etc. shall be perpendicular to the metal flow line direction (that is, the inspection surface is parallel to the metal flow line direction). Under normal circumstances, the inspection surfaces of various products are as follows:

- The inspection surface of plates, bars, pipes is the sample surface;

- When the ratio -- of the long side to the short side of forgings or profile samples with rectangular cross-sections -- is less than 3:1, they shall be inspected along two

comply with the provisions of the corresponding product standards.

8.2.3 In the case of meeting the conditions for ultrasonic inspection, the sample inspection shall be carried out in accordance with the following provisions:

- The sample's exit-factory inspection shall be carried out after the final heat treatment of the sample or before packaging;

- The sample quality assessment can be carried out in any process, such as solution heat treatment, cold processing, straightening, machining;

- When the sample is re-heat treated or plastically deformed, it shall be re-inspected;

- When the sample part needs to be machined, it should complete the inspection before machining.

9 Inspection

9.1 Selection of inspection technology and inspection mode

9.1.1 The ultrasonic longitudinal wave inspection mode shall be used to inspect wrought aluminum and magnesium alloy products, so that the sound beam is vertically incident on the inspection surface parallel to the metal flow line. If additional modes are helpful for the quality control of the inspected samples, these additional inspection modes can be used. According to the inspection requirements and defect characteristics, the appropriate inspection mode can be selected for inspection.

9.1.2 When the main plane of the defect is perpendicular to the inspection surface or at a large angle to the inspection surface, the ultrasonic shear wave inspection mode is used for inspection. The shear wave inspection shall be carried out at least twice; the propagation direction of the sound beam of the first scan shall be opposite to that of the second scan.

9.1.3 When the specific ultrasonic inspection technology is not clearly specified in the product standard, the supplier and the buyer shall negotiate and determine the inspection technology, in accordance with Appendix D.

9.1.4 The use of any additional inspection mode and acceptance criteria shall be determined by the supplier and the buyer, written into the order (or contract) or technical agreement, specified in the inspection procedure or inspection process card before the inspection can be implemented.

9.2 Determine the surface inspection resolution

9.2.1 When the surface machining allowance of the inspected sample is not given, the incident surface resolution of the forging shall comply with the provisions of Figure 1;

9.4.2 If the difference is not greater than 2 dB, no correction or compensation is required. If the difference is greater than 2 dB, the difference in acoustic transmission characteristics between the comparison test block and the sample under test shall be compensated, during the initial scan and defect assessment. If the difference is greater than 12 dB or causes the test signal-to-noise ratio to be less than 2:1, the selected comparison test block is not applicable.

9.4.3 The test points on the sample under test for transmission correction test shall be representative, with no less than 4 test points; the lowest ultrasonic response shall be compared with the bottom wave ultrasonic response of the comparison test block test.

9.4.4 If other methods are used or the purchaser has other requirements, the supplier and the buyer shall negotiate and determine the transmission correction method for correction, meanwhile indicate it in the inspection procedure or inspection process card.

9.5 Threshold setting

The defect assessment's threshold setting shall not be greater than 50% of the reference sensitivity amplitude. If the customer has special requirements, it shall be determined by negotiation between the supplier and the buyer.

9.6 Scanning sensitivity setting

When the sensitivity is increased, the noise generated shall not affect the reliability of defect inspection and meet the surface resolution requirements; the threshold setting level is not changed. The noise response is lower than the threshold. The gain can be increased under the inspection benchmark sensitivity. The gain control can be increased by 10 dB at most, for initial scanning.

9.7 Reliability verification of inspection of special types of defects

After consultation between the supplier and the buyer, it should select two or more representative natural defect comparison samples from the inspected samples, to verify the correctness and effectiveness of the inspection mode, probe parameters, ultrasonic reference reflectors, inspection parameters, the inspection sensitivity settings of certain special types of defects (such as compound filling of thick-walled tube hot cracks, poor extrusion welding, shrinkage, etc.), to ensure the reliability of the inspection results of such defects.

9.8 Dynamic scanning verification

In automatic inspection, a dynamic test reference sample containing a known ultrasonic reference reflector is used for dynamic scanning, to verify the correctness, effectiveness, reliability of the inspection parameters, inspection sensitivity settings, all probes (multi-channel inspection) inspections; verify the inspection capability of inspection resolution. The inspection data collected during the inspection process shall effectively display the minimum defect required by the acceptance level. If the inspection results are displayed

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