GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 77.160

CCS H 16

GB/T 41706-2022

Metallic powders - Test method for determination of non-metallic inclusions in metal powders for powder forging

金属粉末 粉末锻造用金属粉末中非金属夹杂物的测定方法

(ISO 13947:2011, Metallic powders - Test method for the determination of non-metallic inclusions in metal powders using a powder-forged specimen, MOD)

Issued on: October 12, 2022 **Implemented on: October 12, 2022**

Issued by: State Administration for Market Regulation;
Standardization Administration of PRC.

Table of Contents

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Safety precautions -- This document does not specifically point out all safety issues. If safety issues are involved, it is also proposed in combination with the usage situation. It is the responsibility of the user of this document to establish appropriate safety and health protection measures and to clarify the applicability of relevant provisions prior to use.

1 Scope

This document specifies a metallographic method for determining the content of non-metallic inclusions in metallic powders by using powder-forged samples. This measurement method requires that the powder-forged sample has as little lateral flow as possible (<1%) during forging, and requires that the central area of the powder-forged sample has no visible pores under the magnification of 100×.

This document applies to the detection of non-metallic inclusion content in powder-forged parts. In parts with a large amount of lateral flow of material, the separation distance between nearest neighbors needs to be adjusted, or the size of inclusions that need to be adjusted can be determined through negotiation between relevant parties.

This document does not apply to the determination of the level of non-metallic inclusions in internal porous forgings. Residual porosity is difficult to distinguish from inclusions during the magnification in the test. Too much residual porosity makes inclusion distribution determination difficult.

This document can be applied to the detection of materials containing manganese sulfide (pre-mixed or pre-alloyed). In order to meet the test of this type of material, the nearest neighbor separation distance needs to be adjusted from 30 μm to 15 μm.

2 Normative references

The following documents contain the provisions which, through normative reference in this document, constitute the essential provisions of this document. For the dated referenced documents, only the versions with the indicated dates are applicable to this document; for the undated referenced documents, only the latest version (including all the amendments) is applicable to this document.

ASTM B796 Standard test method for nonmetallic inclusion content of powders

-- The powder used for forming the sample (part) does not meet the requirements of the quality standard for the content of non-metallic inclusions;

-- The following reactions occur during the processing of the sample (part): oxidation and/or reduction.

5.4 The use of the nearest neighbor concept will provide a more conservative assessment of inclusions: usually, their contents are overestimated rather than underestimated.

6 Instruments and equipment

6.1 Sample preparation equipment: it is used for the preparation of samples for metallographic testing.

6.2 Metallographic microscope: It can be used for observation and measurement with a magnification of 100×; the wavelength of light is 544 nm (green filter), the magnification of the objective lens is 8×~12.5×, and the numerical aperture is 0.16~0.20.

NOTE: The designated optical element is very important as it determines the object features that can be resolved by the microscope, which is used for assessing inclusion sizes.

7 Samples

7.1 In order to evaluate the non-metallic inclusion content of powders for powder forging, the powders shall be mixed with appropriate quantities of graphite and lubricant and pressed to a specified green density. The test method requires as little lateral flow as possible (<1%) during forging, so the diameter of the green compact relative to the diameter of the forging die shall meet this requirement accordingly.

7.2 The metallographic sample shall be removed from the powder-forged sample (part) for austenitizing and quenching treatment. The heat treatment of the sample can avoid the smearing effect and scratches caused by the soft inclusions, which is beneficial to the sample preparation.

7.3 The area of the polished surface of the sample (part) to be inspected shall not be less than 350 mm^2. For small parts, multiple sections are allowed to be inspected to obtain the required area for measurement.

7.4 The polished surface shall be parallel to the direction of force, that is, the forging direction, and shall be able to represent the central area of the sample (part).

8 Test steps

8.1 Sample preparation

When polishing samples, it is very important to obtain a clean polished surface and that the inclusions are not pitted, tailed, or obscured. Therefore, the procedures specified in ASTM E3 and ASTM E768 shall be followed. An automatic grinding and polishing program is recommended. Samples are examined in polished condition and must not be affected by any prior corrosion (if any).

8.2 Determination of non-metallic inclusion content

8.2.1 The measurement area of the surface of the polished sample shall not be less than 350 mm^2, measured at a magnification of 100×; the wavelength of light used is 544 nm (green filter), the magnification of the objective lens is 8×~12.5×, and the numerical aperture is 0.16~0.20.

8.2.2 Measure the size of inclusions according to the principle of nearest-neighbor separation.

Two inclusions within a distance of 30 μm (0.03 mm) (within 3 mm at 100× magnification) are regarded as the same inclusion.

8.2.3 According to the principle of nearest neighbor separation, three inclusions whose individual size is less than 30 μm and whose distance is less than 30 μm each other are regarded as an inclusion cluster.

8.2.4 According to the principle of nearest neighbor separation, if the distance between two inclusions is within 30 μm, then the individual inclusion with a size smaller than 30 μm is regarded as a part of the inclusions larger than 30 μm. An example is shown in Figure 2.

8.2.5 Detect and record the number of inclusion particles according to the principle of nearest neighbor separation, and use the maximum Feret diameter to determine the size, namely:

-- the length that is greater than or equal to 30 μm,

-- the length that is greater than or equal to 100 μm,

-- the length that is greater than or equal to 150 μm.

In addition to using the concept of nearest-neighbor separation to determine the size of inclusions, the size of individual inclusion particles can also be measured.

8.2.6 If the size of the inclusion is determined separately, the maximum Feret diameter

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