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GB/T 46763-2025

Evaluation method for the grain boundary diffusion result of sintered rare earth iron boron permanent magnets

稀土铁硼烧结永磁体晶界扩散效果评价方法

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1 Scope

GB/T 46763-2025 is the Chinese national standard covering judging a grain boundary diffusion treatment - the depth the dysprosium or terbium actually penetrated, its distribution measured across the section, and the coercivity gained for the heavy rare earth spent, which is the whole point of the process. Grain boundary diffusion is how a magnet maker cuts its dysprosium bill without losing high-temperature coercivity. First edition. Issued on 2 December 2025, it has been in force since 1 July 2026.

This document describes the evaluation method for the magnetic properties and diffusion element content of grain boundary diffusion result of sintered rare earth iron boron permanent magnets. This document applies to the evaluation of heavy rare earth grain boundary diffusion result in sintered rare earth iron boron permanent magnets using the upper and lower surfaces or multiple surfaces. NOTE. Application recommendations for the evaluation method for grain boundary diffusion are provided in Annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 3217 Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties

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

GB/T 29628 Guides for methods of measurement of the magnetic properties of permanent (magnetically hard) materials by pulsed field magnetometry

GB/T 42160 Grain boundary diffusion neodymium iron boron permanent magnet materials

3 Terms and definitions

For the purpose of this document, the terms and definitions defined in GB/T 42160 and the following apply.

3.1 knee coercivity Hk Magnetic field strength corresponding to the decrease in magnetic polarization (4piM) to 90 % of remanence (Br) on the 4piM-H demagnetization curve of a permanent magnet material.

4 Evaluation method for magnetic properties

4.1 Principle Measure the magnetic properties of the magnet before grain boundary diffusion and after aging heat treatment, and the magnetic properties of the magnet after grain boundary diffusion. Based on the measured values, calculate the increase in intrinsic coercivity of the magnet after grain boundary diffusion, the ratio of internal intrinsic coercivity to overall intrinsic coercivity of the magnet, and the ratio of internal knee coercivity to overall knee coercivity of the magnet.

4.2 Measurement of magnetic properties of samples before grain boundary diffusion

4.2.1 The magnets before grain boundary diffusion treatment, after aging heat treatment, are processed into circular magnetic sheets with a diameter of 9 mm ~ 10 mm and a thickness of 2 mm ~ 10 mm, or rectangular magnetic sheets with a side length of 7 mm ~ 10 mm and a thickness of 2 mm ~ 10 mm.

4.2.2 Measure the intrinsic coercivity (HcJ1) and knee coercivity (Hk1) of the samples at room temperature according to the methods specified in GB/T 3217 or GB/T 29628.

4.3 Measurement of overall magnetic properties of samples after grain boundary diffusion

4.3.1 After grain boundary diffusion, the residual diffusion source material and oxides on the magnet sample surface are completely removed by grinding. The surface thickness removed by single-sided grinding is 50 μm ~ 100 μm.

4.3.2 After removing residual diffusion sources from the surface, if the sample size is too large to be directly tested for magnetic properties, the sample can be processed into a circular magnetic sheet with a diameter of 9 mm ~ 10 mm and a thickness of 2 mm ~ 10 mm, or a rectangular magnetic sheet with a side length of 7 mm ~ 10 mm and a thickness of 2 mm ~ 10 mm, without changing the sample's main diffusion direction (usually the easy magnetization direction).

4.3.3 Measure the intrinsic coercivity (HcJ2) and knee coercivity (Hk2) at room temperature of the sample according to the methods specified in GB/T 3217 or GB/T 29628.

4.3.4 The deviation between the temperature during measurement and the temperature at which the magnetic properties of the sample were measured before grain boundary diffusion shall not exceed 0.5 °C.

4.4 Measurement of internal magnetic properties of samples after grain boundary diffusion

4.4.1 After measuring the overall magnetic properties of the sample after grain boundary diffusion, symmetrically grind the main diffusion surfaces on both sides to the required final thickness. The thickness deviation between the two main diffusion surfaces shall be less than

0.1 mm. The sample thickness for measuring the internal magnetic properties of the grain boundary diffused magnet shall be

4.4.2 Measure the intrinsic coercivity (HcJ3) and knee coercivity (Hk3) at room temperature of the sample according to the methods specified in GB/T 3217 or GB/T 29628.

4.4.3 The deviation between the temperature during measurement and the temperature at which the magnetic properties of the sample were measured before grain boundary diffusion shall not exceed 0.5 °C.

4.5 Calculation of evaluation parameters of magnetic properties

4.5.1 Increase in intrinsic coercivity at room temperature of magnet after grain boundary diffusion The improvement in the overall magnetic properties of the magnet after grain boundary diffusion is expressed as the increase in intrinsic coercivity at room temperature (delta), calculated according to formula (1). where. HcJ2 - the intrinsic coercivity at room temperature of the magnet after grain boundary diffusion, in kilo-oerste (kOe); HcJ1 - the intrinsic coercivity at room temperature of the magnet after aging heat treatment and before grain boundary diffusion, in kilo-oerste (kOe).

4.5.2 Ratio of internal magnetic properties to overall magnetic properties of magnets after grain boundary diffusion The ratio of internal magnetic properties to overall magnetic properties of the magnet after grain boundary diffusion is expressed as the ratio of internal intrinsic coercivity (sigma) to overall intrinsic coercivity of the magnet and the ratio of internal knee coercivity

5 Evaluation method for diffusion element content

5.1 Principle The content and variation trend of diffusion elements within a certain depth range on and inside the permanent magnet are measured using X-ray fluorescence spectrometry to evaluate the grain boundary diffusion result.

5.2 Instrumentation X-ray fluorescence spectrometers are divided into wavelength dispersive type and energy dispersive type, and shall meet the requirements of Table 2.
Table 2 -- Requirements for X-ray fluorescence spectrometers

5.3.1 Reference samples

5.3.1.1 Use sintered rare earth iron boron permanent magnets with known single terbium (Dy) and dysprosium (Tb) contents as reference samples.

5.3.1.2 The mass fraction of single element Dy or Tb in the reference samples should preferably be one of the following values. 0, 0.5 %, 1 %, 2 %, 3 %, 5 %, 7 %, or 10 %.

5.3.1.3 The reference samples shall be circular or square sheets with a diameter or side length of 12 mm ~ 20 mm and a thickness of 5 mm ~ 10 mm.

5.3.1.4 The surface of the reference samples shall be uniform in color, clean, and flat, free from visible defects such as sand holes, cracks, and oxides, and shall be wrapped in rust-proof paper for preservation.