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Determination for Coating Adhesion of Rare Earth Permanent Magnetic Materials for Drive Motor of New Energy Vehicle

新能源汽车驱动电机用稀土永磁材料表面涂镀层结合力的测定

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1 Scope

This Standard specifies the determination method for coating adhesion of rare earth permanent magnetic materials for the drive motors of new energy vehicles. There are four methods in total, including the pull method, shear method, cross-cut method and thermal shock method, all of which are destructive test methods.

This Standard is applicable to the determination of the single-layer or multi-layer coating adhesion o of rare-earth permanent magnetic materials for drive motors of new energy vehicles. Coatings include the ones using electroplating, electrophoresis, spraying, physical vapor deposition, chemical plating and coatings other technologies (rare earth permanent magnetic materials with coating are hereinafter referred to as coating products).

NOTE: The pull method and the shear method are suitable for the determination of coating products with a flat surface; and the cross-cut method and thermal shock method are suitable for the determination of coating products of any size.

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 document.

GB/T 3138 Terminology for Metallic Coating - Chemical Treatment and Related Process

GB/T 8170 Rules of Rounding off for Numerical Values & Expression and Judgement of Limiting Values

GB/T 12609 Electrodeposited Metallic Coatings and Related Finishes - Sampling Procedures for Inspection by Attributes

JJG 475-2008 Verification Regulation of Electronic Universal Testing Machine

4.2.3.2 Test column

The test column is composed of a stainless-steel cylinder. One end of the test column is connected to the tensile testing machine; and the other end is bonded with the coating by adhesive. The bonding surface of the test column shall be perpendicular to the axis of the test column (90°±0.5°); and the edges shall be kept at a right angle without chamfering. The surface needs to be polished, and the surface roughness *R*α value of the polished surface is in the range of 0.4μm~12.5μm, which may be adjusted appropriately according to the properties of the adhesive. The diameter of the bonding surface of the test column is 10mm~20mm, and the length of the test column is no less than its diameter.

If the coating product is a non-planar product such as a tile shape, the bonding surface of the test column shall be processed to a corresponding arc according to the size of the coating product to ensure that the bonding surface of the test column may be closely attached to the bonding surface of the coating.

4.2.3.3 Steel sheet

The thickness of the steel sheet is 5mm to ensure that no deformation occurs during the test. The area of the bonding surface of the steel sheet shall be greater than the area of the test surface of the coating product. The upper and lower surfaces shall be smooth, and the roughness *R*α value shall be in the range of 0.4μm~12.5μm.

4.2.4 Adhesive

4.2.4.1 The bonding strength of the adhesive shall be greater than the adhesion between the coating and the substrate under test; and it cannot react with the coating. polyurethane methacrylate or epoxy resin adhesives may be used. If the measurement results of different adhesives are different, the measurement result with the lower acceptance value shall be adopted. In order to reduce the influence of the adhesive itself on the measurement results, the same adhesive shall be used as much as possible.

4.2.4.2 The use and curing of the adhesive shall be carried out in accordance with the technical requirements of its manufacturer. Since heating may change the adhesion of the coating, the curing temperature should be no higher than 100°C, and the heating time should not exceed 30min.

4.3 Sampling

Sampling according to the sampling plan specified in GB/T 12609; 5 or more pieces of each batch of products shall be randomly sampled.

4.4 Specimen

The test surface of the coating product shall be regular, without deformation such as deflection or skew; and the area of the test surface shall be larger than the area of the selected test column. Due to the particularity of rare earth permanent magnetic materials, the specimens shall not be replaced by standard sample boards or products of other specifications.

4.5 Test environment temperature

The test shall be carried out in an environment with a temperature of 10°C~30°C and a relative humidity of 30%~70%.

4.6 Test procedure

4.6.1 Pre-treatment of the sample

Refer to the test Na in GB/T 2423.22: the rapid temperature change part of the specified conversion time conducts the high and low temperature alternating treatment against the coating products. Expose the coating product to a low temperature of (-40 ± 5) °C, keep it for 30min, then convert the coating product to a high temperature of (120 ± 5) °C, continuously keep it for 30min, and the conversion time should not exceed 3min. After many cycles, observe whether the coating is blistering or peeling off by naked eyes. Unless otherwise specified in relevant specifications, the preferred number of test cycles is 5.

4.6.2 Preparation of test samples

Wipe the oil stains on the surfaces of the coated product, test column or steel sheet by absolute ethanol. Apply the adhesive as evenly and thinly as possible on the surface of the coating product, the test column or the steel sheet; and it is required to produce a firm and continuous bonding surface among the coating product, the test column and the steel sheet. During the curing period of the adhesive, connect the coating layer (near the center) coated with the adhesive to the test column or steel sheet; and remove the spilled adhesive during the bonding process in time. After the adhesive is completely cured, if there is still adhesive around the test column, use a blade to remove it.

NOTE: Too much adhesive or adhesive is not evenly coated, which easily causes the applied load not to be perpendicular to the surface of the coating, and further affects the accuracy of the test results.

4.6.3 Test

Fix the test device in the upper and lower clamps of the tensile testing machine; and apply the tensile force to evenly act on the test surface. There shall be no torsion or slippage between the adhesive surface and the test column. Apply a tensile force in the normal direction of the test surface of the coated product; and the moving speed

Key:

1 – substrate;

2 – adhesive;

3 – coating on the substrate surface;

4 – test column;

5 – fixture base;

6 – bonding area;

F - compressive force.

Figure 2 – Schematic Diagram for Test Device of Shear Method

5.2.3.2 Test column

The test column is composed of stainless steel. The bonding surface of the test column shall be perpendicular to the base part (90°±0.5°); and the edges shall be kept at a right angle without chamfering. The bonding surface needs to be polished; and the polished surface roughness *R*α value is 0.4μm~12.5μm. Within the range, it can be adjusted appropriately according to the properties of the adhesive. The size of the bonding surface of the test column is 10mm×10mm.

5.2.4 Adhesive

The requirements for the adhesive are the same as 4.2.4.

5.2.5 Safety shield

It is used to prevent the broken pieces of the specimen from flying out and hurting the test personnel.

5.3 Sampling

Sampling according to the sampling plan specified in GB/T 12609; 5 or more pieces of each batch of products shall be randomly sampled.

5.4 Specimen

The test surface of the coating product is flat, and there shall be no deformation such as deflection or skew; and the area shall be larger than the area of the selected test column. Due to the particularity of rare earth permanent magnetic materials, the specimens to be tested shall not be replaced by standard templates or products of other specifications.

5.5 Test environmental conditions

The test shall be carried out in an environment at a temperature of 10°C~30°C and a relative humidity of 30%~70%.

5.6 Test procedures

5.6.1 Pretreatment of the specimen

The pretreatment method of the specimen shall be carried out according to 4.6.1.

5.6.2 Preparation of the test sample

Wipe clean the oil stains on the bonding surface of the coating product and the test device by absolute ethanol. The rest is the same as 4.6.2.

5.6.3 Test

Fix the test device in the pressure testing machine and use a suitable safety shield for protection. Apply a compressive force in a direction parallel to the measured plane of the coating product, and the moving speed of the beam of the pressure testing machine shall be controlled at a constant value in the range of 0.1mm/min~0.5mm/min, until the coating product is separated from the test column. Record the maximum compressive force *F* that separates the coating product from the test column.

5.7 Test results

5.7.1 The adhesion τ (in MPa) of the coating of rare earth permanent magnetic material shall be calculated by Formula (2):

$$\tau = \frac{F}{A} \qquad \cdots\cdots (2)$$

Where:

F - the maximum force that separates the coating product from the test column, in N;

A - the bonding area between the coating product and the test column, in mm^2.

5.7.2 If the rare earth permanent magnetic material is tile-shaped and other non-planar specifications, use the maximum force value *F* to replace the adhesion τ index ($\tau = F$); meanwhile mark the arc length, curvature radius and other dimensions of the bonding surface of the test column.

5.7.3 The binding force calculation results are rounded-off according to GB/T 8170, accurate to the one digit after the decimal point. The test results of the same batch of samples are expressed by the arithmetic mean, highest value and lowest value of the adhesion.

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