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Diamond-like carbon films — Determination of friction and wear characteristics of diamond-like carbon films by ball-on-disc method

Revêtements de carbone amorphe — Détermination des caractéristiques de frottement et d'usure des revêtements de carbone amorphe par la méthode bille sur disque



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 107, *Metallic and other inorganic coatings*.

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Introduction

This International Standard gives guidance on conducting a sliding friction and wear test in a ball-on-disc configuration to determine the friction generated and wear observed in uniaxial sliding contacts between diamond-like carbon (DLC) films and a counter body.

The tribological properties of DLC films are different from those of metallic and ceramic coatings. DLC films have the tribological characteristics of low friction and low wear against other materials. Since a DLC film is a coating, rather than a bulk material, it has a limited amount of wear and possibility of delamination. Hence, a friction and wear testing method specific to DLC films is used to determine friction and wear resistance independent of delamination. In the ball-on-disk method using a DLC-coated ball on a non-coated disk, a non-coated ball on a DLC-coated disk, or a DLC-coated ball on a DLC-coated disk, the wear of DLC is minimal compared with other materials; for this reason, it is preferable to apply the coating on the ball to measure the wear rate with a reasonable accuracy. Of course, the wear on the ball side induces a decrease in contact pressure that must be taken into account for the friction coefficient interpretation. Because of these aspects, the ball-on-disk method is ideal for conventional testing of DLC coatings.

It should be noted that there are many parameters in the sliding contact that affect the magnitude of friction and wear. The aim of performing any wear test is to simulate, as closely as possible, the conditions that occur in the real application. As the deviation between the test conditions and the application conditions becomes larger, the test results become less relevant. To add credence to the test results, the appearance of the worn surfaces from the test samples are compared with the appearance of the worn surface from the actual worn component in order to ensure that similar wear mechanisms have taken place in each case. It is intended that the recommended test conditions suggested in this International Standard be used when the application conditions are not well defined but general comparison among materials is required.

This International Standard is useful for quality control of DLC films.

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Diamond-like carbon films — Determination of friction and wear characteristics of diamond-like carbon films by ball-on-disc method

1 Scope

This International Standard specifies a procedure for and provides guidance on the determination of the coefficient of friction and the specific wear rate of diamond-like carbon (DLC) films. The method specifies that the materials are tested under dry conditions in pairs in a ball-on-disc configuration.

The results of the tests are not applicable when DLC-coated parts operate in a lubricated environment.

2 Normative references

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

ISO 1101, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 3274, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

ISO 3290-1, *Rolling bearings — Balls — Part 1: Steel balls*

ISO 3290-2, *Rolling bearings — Balls — Part 2: Ceramic balls*

ISO 3611, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 13385-1, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Callipers; Design and metrological characteristics*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
wear
progressive mass removal from the surface of solid material due to relative motion with a contacting substance or substances

3.2
wear test
method of evaluating the friction and wear performance of materials in sliding contact

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3.3
ball-on-disc method
wear test method in which the sliding contact is brought about by pushing a ball specimen on to a rotating disc specimen under a constant load

3.4
friction force
resisting force tangential to the interface between two bodies, when one body moves or tends to move relative to the other under the action of a normal force pressing these bodies together

3.5
coefficient of friction
μ
dimensionless ratio of the friction force, F_f, to the applied normal force, F_p

Note 1 to entry: $\mu = F_f / F_p$.

3.6
specific wear rate
W_s
rate of material removal by wear, expressed by means of the wear volume, V, per unit applied normal force, F_p, and unit sliding distance, L

Note 1 to entry: $W_s = V/(F_p \times L)$.

4 Test materials and specimen preparation

4.1 Materials

This ball-on-disc testing method can be applied to DLC coatings. The only requirement is that the ball and disc specimens having the dimensions specified below can be prepared and that they shall withstand the stresses imposed during the testing without failure or excessive flexure.

Using the ball-on-disk method, either the ball or the disk or both the ball and disk can be used as substrates of the DLC films for testing depending on the requirements. The thickness of DLC films shall be 0,01 μm to 10 μm.

Any pertinent details of ball and disk specimen such as their dimensions, surface finish, material type, composition, microstructure, and processing treatments shall be supplied.

4.2 Ball specimen

The ball specimen shall be a true sphere of more than 5 mm in diameter or a straight rod whose end part is machined to a spherical cap. The recommended diameter of the sphere is 6 mm. The surface roughness of the specimen shall not be more than 0,1 μm *Ra* as specified in ISO 4287. The Rpk value of the surface roughness should be measured and noted in the test report. Ball sphericity shall follow ISO 3290-1 and ISO 3290-2.

4.3 Disc specimen

The disc specimen shall be more than 3 mm in thickness and be large enough to enable the testing surface to contain a sliding circle of 3 mm in diameter with a minimum of 1 mm of clearance between the circle exterior and the edge of the coated region. The surfaces of the disc shall be flat and parallel to within 0,02 mm as specified in ISO 1101. The roughness of the test surface shall not be more than 0,02 μm *Ra* as specified in ISO 4287. It is recommended that "*Ra*" be used as the symbol for roughness. The Rpk value of the surface roughness should be measured and noted in the test report. Where it is necessary to use such symbols for other parameters, these shall also be specified.

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