Nederlandse

norm

Ontwerp

NEN-EN 12290

Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere - Determination of compression properties

Publicatie uitsluitend voor commentaar

december 2004
ICS 81.060.30

Commentaar voor 2005-03-09

Zal vervangen NVN-ENV 12290:1996

Als Europees normontwerp is gepubliceerd: prEN 12290:2004,IDT

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Normcommissie 342 032 "Technische keramiek"

NEN

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

FINAL DRAFT
prEN 12290

December 2004

ICS 81.060.30 — Will supersede ENV 12290:1996

English version

Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere - Determination of compression properties

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites à haute température en atmosphère neutre - Détermination des caractéristiques en compression

Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur in inerter Atmosphäre - Bestimmung der Eigenschaften unter Druck

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. prEN 12290:2004: E

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Foreword

This document (prEN 12290:2004) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This document is currently submitted to the Unique Acceptance Procedure.

This document will supersede ENV 12290:1996.

1 Scope

This European Standard specifies the conditions for determination of compression properties of ceramic matrix composite materials with continuous fibre reinforcement for temperatures up to 2 000 °C under vacuum or a gas atmosphere which is inert to the material under test.

NOTE The use of these environments is aimed at avoiding changes of the material to be tested due to chemical reaction with its environment during the test.

This European Standard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional (xD, with $2 < x \leq 3$), loaded along one principal axis of reinforcement.

Two types of compression are distinguished:

a) compression between platens;

b) compression using grips.

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.

EN 10002-4, *Metallic materials - Tensile test - Part 4: Verification of extensometers used in uniaxial testing.*

EN 60584-1, *Thermocouples - Part 1: Reference tables (IEC 60584-1:1995).*

EN 60584-2, *Thermocouples — Part 2: Tolerances (IEC 60584-2:1982 + A1:1989).*

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force measuring system (ISO 7500-1:2004).*

ISO 3611, *Micrometer callipers for external measurement.*

3 Terms, definitions and symbols

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

3.1
test temperature, T
temperature of the test piece at the centre of the gauge length

3.2
calibrated length, l
part of the test specimen that has uniform and minimum cross-section area

3.3
gauge length, L_o
initial distance between reference points on the test specimen in the calibrated length

3.4
controlled temperature zone
part of the calibrated length including the gauge length where the temperature is within a range of 50 °C of the test temperature

3.5
initial cross-section area, A_o
initial cross-section area of the test specimen within the calibrated length, at test temperature

3.6
longitudinal deformation, ΔL
decrease in the gauge length L between reference points under a compression force

NOTE Its value at maximum force is denoted $\Delta L_{c,m}$.

3.7
compression strain, ϵ
relative change in the gauge length defined as the ratio $\Delta L/L_o$

NOTE Its value at maximum force is denoted as $\epsilon_{c,m}$.

3.8
compression stress, σ
compression force supported by the test specimen at any time in the test divided by the initial cross-section area (A_o)

3.9
maximum compression force, F_m
highest recorded compression force in a compression test on the test specimen when tested to failure

3.10
compression strength, $\sigma_{c,m}$
ratio of the maximum compression force (F_m) to the initial cross-section area (A_o)

3.11
proportionality ratio or pseudo-elastic modulus, E_p
slope of the linear section of the stress-strain curve, if any

NOTE Examination of the stress-strain curves for ceramic matrix composites allows definition of the following cases:

a) Material with a linear section in the stress-strain curve.

For ceramic matrix composites that have a mechanical behaviour characterized by a linear section, the proportionality ratio is defined as:

$$Ep\,(\sigma_1, \sigma_2) = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - \varepsilon_1} \tag{1}$$

where

(ϵ_1, σ_2) and (ϵ_2, σ_2) lie near the lower and upper limits of the linear section of the stress-strain curve.

The proportionality ratio or pseudo-elastic modulus is termed the elastic modulus, E, in the single case where the material has a linear behaviour from the origin.

b) Material with no-linear section in the stress-strain curve.

In this case only stress-strain couples can be fixed.

4 Principle

A test specimen of specified dimensions is heated to the test temperature, and loaded in compression. The test is performed at constant crosshead displacement rate, or constant deformation rate. Force and longitudinal deformation are measured and recorded simultaneously.

NOTE 1 The test duration is limited to reduce creep effects.

NOTE 2 Constant loading rate is only allowed in the case of linear stress-strain behaviour up to failure.

NOTE 3 In order to protect fixtures, it is recommended to use constant crosshead displacement rate when the test is carried out until rupture.

5 Apparatus

5.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen which shall conform to grade 1 or better according to EN ISO 7500-1.

NOTE This should prevail during actual test conditions of, e.g. gas pressure and temperature.

5.2 Load train

The load train configuration shall ensure that the load indicated by the load cell and the load experienced by the test specimen are the same.

The load train performance including the alignment system and the force transmitting system shall not change because of heating.

There are two alternative means of load application.

a) Compression platens are connected to the load cell and on the moving crosshead. The parallelism of these platens shall be better than 0,01 mm, in the loading area, at room temperature and they shall be perpendicular to the load direction.

NOTE 1 The use of platens is not recommended for compression testing of 1D and 2D materials with low thickness due to buckling.

NOTE 2 A compliant interlayer material between the test specimen and platens may be used for testing macroscopically inhomogeneous materials to ensure even contact pressure. This material should be chemically compatible with both test specimen and platen materials.

b) Grips are used to clamp and load the test specimen.

The grip design shall prevent the test specimen from slipping. The grips shall align the test specimen axis with that of the applied force.

NOTE 3 Conformity with this requirement should be verified and documented according to, for example, the procedure described in reference [1].

NOTE 4 The grips or the platens may either be in the hot zone of the furnace or outside the furnace.

NOTE 5 When grips or platens are outside the furnace, a temperature gradient exists between the centre of the specimen, which is at the prescribed temperature, and the ends that are at the same temperature as the grips or platens.

5.3 Gastight test chamber

The gastight chamber shall allow proper control of the test specimen environment in the vicinity of the test specimen during the test. The installation shall be such that the variation of load due to the variation of pressure is less than 1 % of the scale of the load cell being used.

Where a gas atmosphere is used, the gas atmosphere shall be chosen depending on the material to be tested and on test temperature. The level of pressure shall be chosen depending: on the material to be tested, on temperature, on the type of gas, and on the type of extensometry.

Where a vacuum chamber is used, the level of vacuum shall not induce chemical and/or physical instabilities of the test specimen material, and of extensometer rods, when applicable.

5.4 Set-up for heating

The set-up for heating shall be constructed in such a way that the temperature gradient within the gauge length is less than 20 °C at test temperature.

5.5 Extensometer

The extensometer shall be capable of continuously recording the longitudinal deformation at test temperature.

NOTE 1 The use of an extensometer with the greatest possible gauge length is recommended.

The linearity tolerance shall be less than or equal to 0,15 % of the extensometer range used.

The extensometer shall conform to class 1 or better of EN 10002-4. Two commonly used types of extensometer are the mechanical extensometer and the electro-optical extensometer.

If a mechanical extensometer is used, the gauge length shall be the initial longitudinal distance between the two locations where the extensometer rods contact the test specimen.

The rods may be exposed to temperatures higher than the test specimen temperature. Temperature and/or environment induced structural changes in the rod material shall not affect the accuracy of deformation measurement. The material used for the rods shall be compatible with the test specimen material.

NOTE 2 Care should be taken to correct for changes in calibration of the extensometer that may occur as a result of operating under conditions different from calibration.

NOTE 3 Rod pressure onto the test specimen should be the minimum necessary to prevent slipping of the extensometer rods.

If an electro-optical extensometer is used, electro-optical measurements in transmission require reference marks on the test specimen. For this purpose rods or flags shall be attached to the surface perpendicular to its axis. The gauge length shall be the distance between the two reference marks. The material used for marks (and adhesive if used) shall be compatible with the test specimen material and the test temperature and shall not modify the stress field in the specimen.

NOTE 4 The use of integral flags as parts of the test specimen geometry is not recommended because of stress concentration induced by such features.