SLOVENSKI STANDARD
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Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere - Determination of flexural strength

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Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur an inerter Atmosphäre - Bestimmung der Biegefestigkeit

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites a haute température sous atmosphere inerte - Détermination de la résistance en flexion

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This European Standard was approved by CEN on 18 July 2005.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This European Standard (EN 12788:2005) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2006, and conflicting national standards shall be withdrawn at the latest by February 2006.

This document supersedes ENV 12788:1998.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

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

NOTE 1 The use of these environments is aimed at avoiding changes of the material affecting its flexural strength caused by chemical reaction with its environment during the test.

This European document 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.

NOTE 2 The method outlined in this document should not be used to obtain values of flexural strength for design purposes.

2 Normative references

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

EN 12789, *Advanced technical ceramics — Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure — Determination of flexural strength*

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

EN 60584-2:1993, *Thermocouples — Part 2: Tolerances (IEC 60584-2:1982 + A1:1989)*

ENV 843-5:1996, *Advanced technical ceramics — Monolithic ceramics — Mechanical tests at room temperature — Part 5: Statistical analysis*

EN ISO 7500-1:1999, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 3611:1978, *Micrometer callipers for external measurement*

3 Terms, definitions and symbols

For the purposes of this European Standard, the following terms, definitions and symbols apply.

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

3.2
maximum flexural force, F_m
highest recorded force in a flexural test on the test specimen when tested to failure

3.3
flexural stress, σ
nominal stress on the outer surface of the test specimen, calculated at mid span

NOTE This stress is conventionally calculated according to the simple beam theory, the basic assumptions of which may not be met by ceramic matrix composite materials.

3.4
flexural strength, $\sigma_{f,m}$
maximum flexural stress applied to a test specimen that fractures during a flexural test

4 Principle

A test specimen of specified dimensions is heated to the test temperature. It is subsequently flexion loaded to fracture in such a way that failure occurs in tension, or in compression, along one principal axis of reinforcement.

The test is performed at constant crosshead displacement rate.

The test duration is limited to reduce any time-dependent effects (e.g. creep).

5 Apparatus

5.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen. The system shall conform to grade 1 according to EN ISO 7500-1:1999.

5.2 Test jig

The test jig is composed of two parts, linked to the fixed and mobile parts of the machine. It has two outer support rollers and one (three-point bending) or two (four-point bending) inner support rollers.

The material of the jig and that of the rollers shall not react with that of the specimen, or with the environment.

The cylindrical rollers shall have a diameter of 4 mm to 10 mm. Their length shall be at least equal to the width of the specimen. They shall be made of a material with a hardness at least equal to that of the specimen. The axes of the rollers shall be parallel to within 0,01 mm/mm.

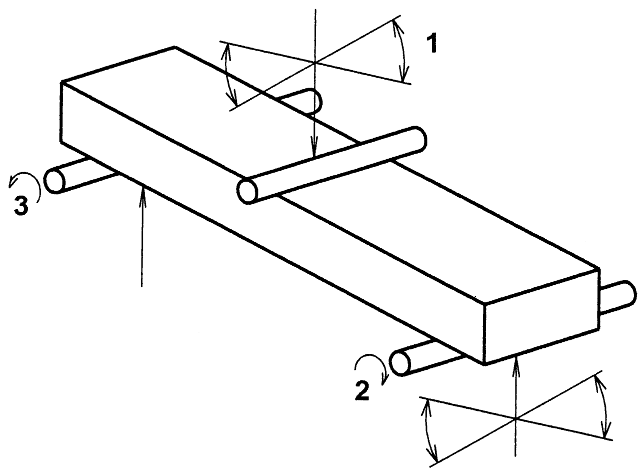
The outer rollers (three and four-point bending) and inner rollers (four-point bending) shall be free to rotate (see Figure 1).

Either two or three rollers, for three-point or four-point bending respectively, shall be free to pivot around an axis parallel to the longitudinal direction of the test specimen, in order to adapt to the non-parallelism of the upper and lower faces of unmachined test specimens (see Figure 1).

The rolling and pivoting ability of the rollers shall not be affected by heating. The distance between rollers shall be in accordance with Clause 6.

The inner roller(s) shall be centred with respect to the outer rollers to within 0,2 mm. In the case of four-point bending, a levelling system shall be used to ensure symmetrical loading of the test specimen.

The performance shall not change because of heating.



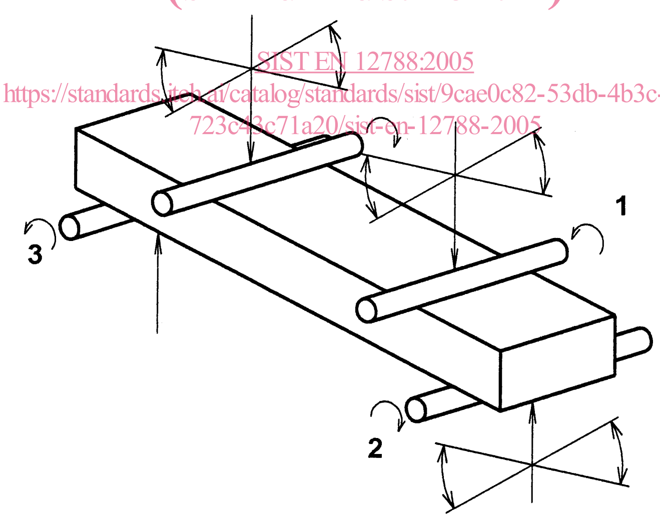
Key

1 Pivoting loading roller

2 Rolling and pivoting support roller

3 Rolling but non-pivoting support roller

a)



Key

1 Rolling and pivoting loading roller

2 Rolling and pivoting support roller

3 Rolling but non-pivoting support roller

b)

Figure 1 — Articulation required for jigs

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 the load during the time of loading, which may occur due to parasitic effects (e.g. variation of pressure, seals, etc.), is less than 1 % of the range of the load cell being used.

Where a gas atmosphere is used, the gas atmosphere shall be inert to the specimen material and test jig under test conditions.

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

5.4 Set-up for heating

The set-up for heating shall be constructed in such a way that the variation of temperature of the test specimen, which is between the outer support rollers, is less than 50 °C at test temperature.

5.5 Temperature measurement devices

For temperature measurement, either thermocouples conforming to EN 60584-1 and EN 60584-2 shall be used or, where thermocouples not conforming to EN 60584-1 and EN 60584-2 are used, they shall be calibrated appropriately.

5.6 Data recording system

A calibrated recorder shall be used to record force-time curve.

NOTE The use of a digital data recording system combined with an analogue recorder is recommended.

5.7 Micrometers

Micrometers used for the measurement of the dimensions of the test specimen shall conform to ISO 3611.

6 Test specimens

The amount of material under load shall be representative of the nature of the material and of the reinforcement structure.

NOTE 1 This sets minimum limits to the span and to the width and thickness of the specimen.

In the case of flexural, as opposed to tensile testing, the distribution of the longitudinal reinforcement through the thickness shall also be considered. When this distribution is not symmetrical with respect to the neutral plane, care shall be taken to insure that it is similar between specimens.

The thickness and the distance between the inner and outer roller(s) shall be chosen so as to avoid shear failure. This is achieved by setting a minimum limit to the ratio between the moment arm and the specimen thickness.

NOTE 2 A value of 10 is commonly used and translates into a minimum L/h ratio of 20 in three-point bending, and a minimum $(L - L_i)$/h ratio of 20 in four-point bending with $L_i = L/3$.

NOTE 3 Other factors affecting the size and dimensions of the specimens are the type of the heating and of the loading system, as well as the size of the test chamber.

Recommended specimen dimensions are given in Table 1.