SLOVENSKI STANDARD
SIST-TS CEN/TS 15880:2009

01-september-2009

Sodobna tehniļ na keramika - Keramiļ ni kompoziti - Ugotavljanje striģne sile vlakna/matrice pri sobni temperaturi z metodo potiska (push-out method)

Advanced technical ceramics - Ceramic composites - Determination of the fibre/matrix interfacial frictional shear stress at room temperature by a single fibre push-out method

Hochleistungskeramik - Keramische Verbundwerkstoffe - Bestimmung der Reibschubspannung an der Grenzfläche Faser/Matrix bei Raumtemperatur mit Hilfe des Einzelfaser-Push-out-Verfahrens

Céramiques techniques avancées - Céramiques composites - Détermination de la contrainte de frottement en cisaillement à l'interface fibre/matrice à température ambiante - Méthode d'extraction d'une fibre par indentation

Ta slovenski standard je istoveten z: **CEN/TS 15880:2009**

ICS:

81.060.30	Sodobna keramika	Advanced ceramics

SIST-TS CEN/TS 15880:2009 **en,de**

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 15880

May 2009

ICS 81.060.30

English Version

Advanced technical ceramics - Ceramic composites - Determination of the fibre/matrix interfacial frictional shear stress at room temperature by a single fibre push-out method

Céramiques techniques avancées - Céramiques composites - Détermination de la contrainte de frottement en cisaillement à l'interface fibre/matrice à température ambiante - Méthode d'extraction d'une fibre par indentation

Hochleistungskeramik - Keramische Verbundwerkstoffe - Bestimmung der Reibschubspannung an der Grenzfläche Faser/Matrix bei Raumtemperatur mit Hilfe des Einzelfaser-Push-out-Verfahrens

This Technical Specification (CEN/TS) was approved by CEN on 27 March 2009 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. CEN/TS 15880:2009: E

Contents

Page

Foreword

This document (CEN/TS 15880:2009) has been prepared by Technical Committee CEN/TC 184 "Advanced technical ceramics", the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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

1 Scope

This CEN Technical Specification specifies a single fibre push-out method to determine the fibre-matrix bonding characteristics of ceramic matrix composite materials at room temperature, by the measurement of the interfacial frictional shear stress.

This standard applies to all continuous fibre-reinforced ceramic matrix composites whatever the type of reinforcement: unidirectional (1D), bidirectional (2D) and tridirectional (xD, with $2 < x \leq 3$).

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.

CEN/TR 13233:2007, *Advanced technical ceramics - Notations and symbols*

ISO 3611, *Micrometer callipers for external measurements*

3 Terms, definitions and symbols

For the purposes of this European Technical Specification, the terms, definitions and symbols given in CEN/TR 13233:2007 and the following apply.

3.1
fibre perimeter
p
perimeter of the fibre

3.2
length of the fibre
L_f
embedded length of the fibre which is equal to the local thickness of the test specimen

3.3
compressive force
F
compressive force on the fibre

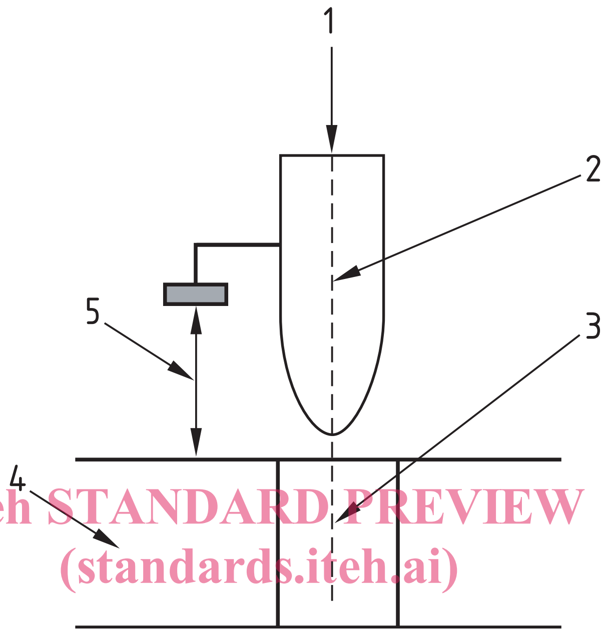
3.4
compressive plateau force
$F_{plateau}$
compressive force on the fibre determined at point "d" of the curve

3.5
interfacial frictional shear stress
τf
shear stress during fibre sliding through the matrix

3.6
fibre top displacement
δ
displacement of the top of the fibre during the test

4 Principle

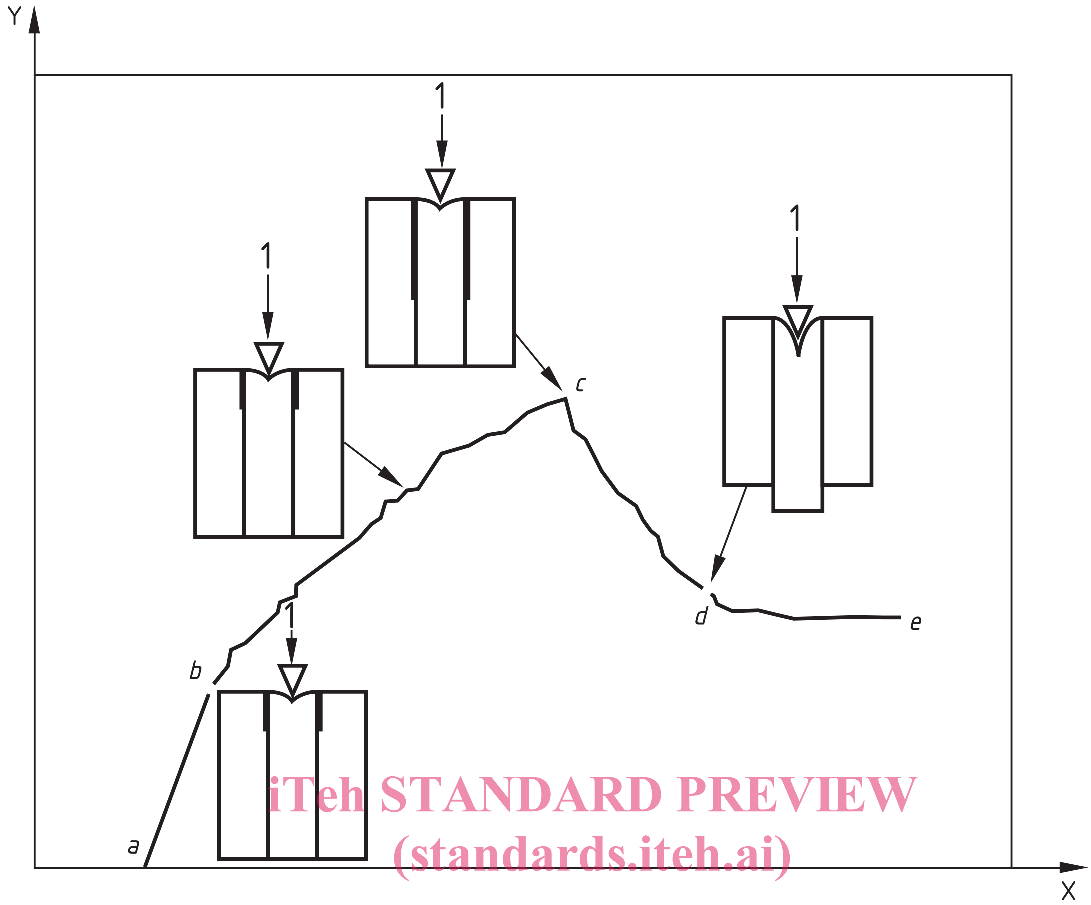
Tests specimens of specific sizes and geometry are used for the tests. A fibre is pushed through the matrix using an indentation tester. A compressive force is applied through an indentor at a constant displacement rate, on top of a single fibre and parallel to fibre axis. The force and the fibre top displacement are measured and recorded simultaneously (see Figure 1). The dimensions of the fibre pushed shall be determined.



Key

1 Force
2 Indentor
3 Selected fibre
4 Matrix
5 Displacement

Figure 1 – Schematic diagram illustrating the principle of the test



Key

X Displacement
Y Force

Figure 2 — Schematic diagram showing a typical single-fibre push-out behaviour for a ceramic matrix composite

Figure 2 exhibits the following steps:

a – b elastic fibre deformation,

b initiation of debonding,

b –c region of progressive (stable) debonding and sliding (push-in),

c instability,

c – d unstable debonding,

d initiation of push-out,

d – e progressive push-out: stable extraction of the embedded fibre (plateau).

The interfacial parameters are extracted from the experimental force versus top-fibre displacement curve. The complete curve “a-e” is obtained by a push-out test, and the interfacial characteristics are determined using the plateau force “d-e”.

5 Significance and use

Ceramic matrix composites display a non-brittle behaviour under tensile loading conditions when the fibre/matrix bond is carefully designed. The fibre/matrix bond cannot be too strong, otherwise the composite will be brittle. The fibre/matrix bond cannot be too weak, otherwise the composite will be unable to withstand high stresses. Interfaces must exhibit an appropriate resistance to cracking to allow, first, matrix crack arrest and damage tolerance, and second, load transfers from the fibre to the matrix. Characteristics fibre/matrix interfaces are therefore of primary importance in composite engineering, evaluation and in predictions of behaviour and performances.

Fibre pushing tests (and more particularly the single fibre push-out tests) are used for the determination of fibre/matrix interface characteristics in composites. This is a powerful tool to evaluate those interfaces controlling the mechanical behaviour. The main advantages of fibre push out tests are the relative simplicity of the test procedure and the fact that single fibres can be selected in the composite.

The method of extraction of interface characteristics critically depends on the shape of the force-displacement curve recorded during the tests. When test specimens are too thick only the push-in portion of the curve can be obtained. When the test specimen is thin enough, the complete curve depicted in Figure 2 is obtained. The shape of the curve may be additionally influenced by interface strength. In the presence of quite strong interfaces, the push-in curve exhibits an upward curvature. In this case, very thin specimens are required to get fibre push out.

The fibre pushing tests allow various characteristics to be determined depending on the portion of the curve considered. The basic data that can be extracted from both the push in and the push out curves, are the interfacial frictional shear stress which measures the ability of a cracked interface to transfer stresses from the fibre to the matrix. In a fibre pushing test, the basic data is given by the shear stress during fibre sliding. The interfaces that are the most efficient from this viewpoint are characterized by high interfacial shear stresses. Such interfaces can be considered to be strong. On the contrary, the less efficient interfaces are characterized by low interface shear stresses. Such interfaces can be considered to be weak. Therefore, the interface shear stress provides an index of interface strength.

This characteristic, as well as the resistance to debonding, can be extracted from both push-in and push-out curves. Extraction of these data from push-in curves relies on quite complex models that can be found in the references in the Bibliography. It is simpler when push-out curves can be produced. However, additional properties such as the coefficient of friction, clamping stress, interface roughness could be extracted from the push-in curves. Determination of interface characteristics from the push-in requires the use of complex relations (see bibliography) and will not be treated in this standard. In the case of push-out, the sliding interfacial stress can be calculated from the stress of the plateau at point "d" on the curve of Figure 2, where sliding of the fibre starts on along its entire length (that is the thickness of the specimen).

Because it requires simpler calculations, the push-out method is the principal experimental method for experimental determination of the interfacial frictional shear stress. This can be generally performed when appropriate thickness of the test specimen is selected.

In addition to the push-out method described here, there also exist other methods to determine the fibre/matrix bond characteristics: the pull-out technique, the tensile tests on mini-composites or composites. Each of these has its relative merits and disadvantages; the selection of an appropriate method has to be considered on a case by case basis.

6 Apparatus

The major components that are needed to run a test are a load cell, a displacement-controlled system equipped with a strain gauge, an indentor, a microscope, a force-displacement recording system, a mobile test specimen holder on a vibration-free table to allow the test specimen to move in the two directions x and y, a system that permits a perfect alignment of the indentor displacement axis with the fibre axis, and a data-acquisition system to store experimental results. Following type of indentor is recommended: flat tip indentor