SLOVENSKI STANDARD
SIST-TS CEN/TS 15881:2009

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Sodobna tehniļ na keramika - Keramiļ ni kompoziti - Ugotavljanje striģne sile vlakna/matrice pri sobni temperaturi z nateznimi preskusi mini kompozitov

Advanced technical ceramics - Ceramic composites - Determination of the fibre/matrix interfacial frictional shear stress at room temperature by tensile tests on mini-composites

Hochleistungskeramik - Keramische Verbundwerkstoffe - Bestimmung der Reibschubspannung an der Grenzfläche Faser/Matrix bei Raumtemperatur mit Hilfe von Zugversuchen an Mini-Verbundwerkstoffen

Céramiques techniques avancées - Céramiques composites - Détermination de la contrainte de frottement en cisaillement à l'interface fibre/matrice à température ambiante - Essais de traction sur minicomposites

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TECHNICAL SPECIFICATION

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English Version

Advanced technical ceramics - Ceramic composites - Determination of the fibre/matrix interfacial frictional shear stress at room temperature by tensile tests on mini-composites

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Contents

Page

Foreword

This document (CEN/TS 15881:2009) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

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1 Scope

This CEN Technical Specification specifies a 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 obtained by cycled tension on mini-composites.

A mini-composite is a unidirectional composite reinforced with a single tow.

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*

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)*

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 radius
Rf
for circular fibres Rf is the mean radius of the fibres; for non circular fibres, Rf is replaced by

$$\sqrt{\frac{S_F}{\pi}}$$

3.2
fibre cross-section area
S_F
mean cross section area of the fibre

3.3
cross section area
A_0
cross section area of the test specimen

3.4
gauge length
L_0
initial distance between the two gripped ends of the test specimen

3.5 Volume fraction

3.5.1
fibre volume fraction
V_f
fraction of fibre content in the test specimen that can be determined using microscopy and image analysis or any other adequate method

3.5.2
matrix volume fraction
V_m
fraction of matrix content in the test specimen that can be determined using microscopy and image analysis or any other adequate method

3.6
tensile force
F
tensile force on the test specimen

3.7
maximum tensile force
F_M
highest recorded tensile force on the test specimen when tested to failure

3.8
initial tensile force at unloading
F_p
tensile force on the test specimen at initiation of unloading

3.9
tensile force at matrix crack saturation
F_s
tensile force on the test specimen at the end of the non linear domain of the force-displacement curve (see Figure 1)

3.10
cycle or hysteresis loop
force-displacement curve obtained when loading the test specimen up to a given defined load and then unloading it to zero load (see Figure 2)

3.11
area of the hysteresis loop
S
area comprised between the unloading and the reloading force-displacement curve during a cycle (see Figure 2)

3.12
width of a hysteresis loop
$\delta\Delta$
difference in measured displacements on unloading and reloading, at a same force, during a cycle (see Figure 2)

3.13
tensile stress
σ
tensile force in the unloading-reloading sequence that corresponds to $\delta\Delta$ divided by the cross section area A_o

3.14
initial stress at unloading
σ_p
tensile force at initiation of unloading divided by the cross section area A_o

3.15
stress at matrix crack saturation
σ_s
tensile force at the end of non linear domain of the monotonic loaded force-displacement curve, divided by the cross-section area A_o (force level F_s in Figure 1)

3.16
longitudinal deformation
ΔL
increase of the gauge length under a given force

3.17
total compliance
C_t
inverse of the slope in the initial linear part of the force/displacement curve

3.18
load train compliance
C_l
ratio of the cross-head displacement to the force excluding any test specimen contribution to the corresponding force during the tensile test

3.19
interfacial frictional shear stress
τf
interfacial frictional shear stress at initiation of sliding between fibre and matrix

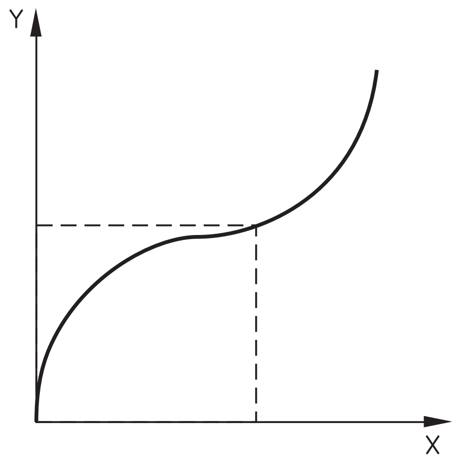
3.20
mean spacing distance of matrix cracks
l_S
mean spacing distance between transverse cracks after matrix cracking saturation

4 Principle

The mini-composite is loaded monotonically in tension parallel to the fibre direction at a constant displacement rate.

4.1 Method A

If saturation of matrix cracking can be detected on the force-displacement curve, then the interfacial frictional shear stress is obtained from the force at crack saturation, F_S (see Figure 1).



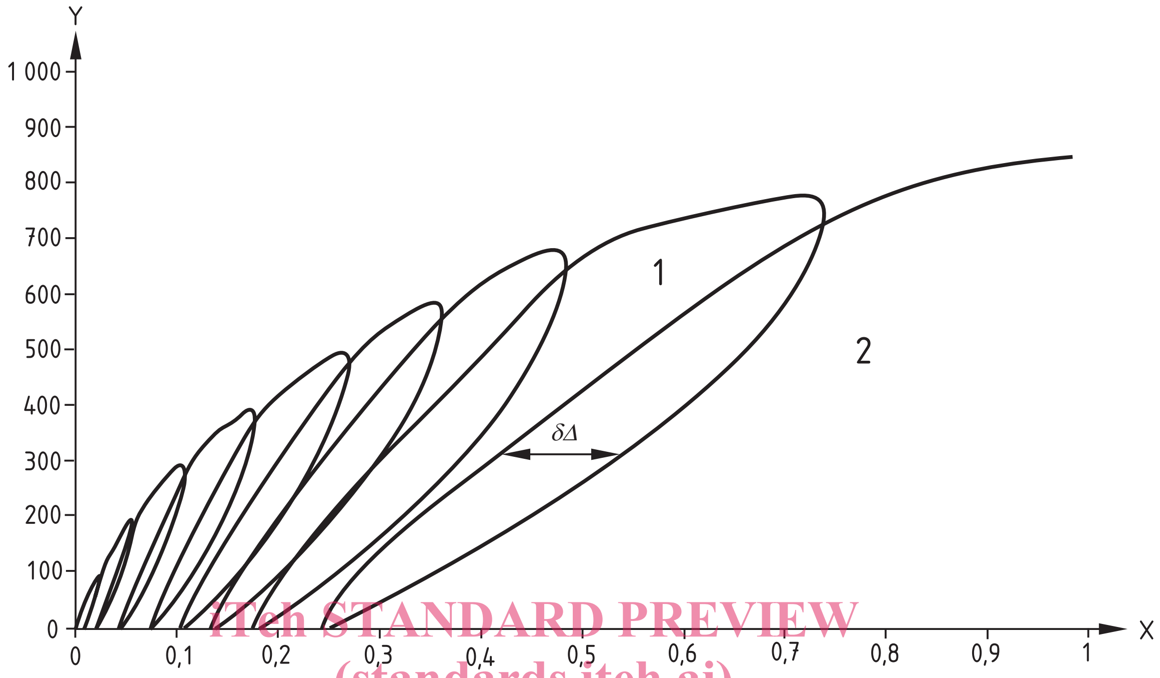
Key

X Displacement
Y Force

Figure 1 – Force-displacement curve obtained during a tensile test (Method A)

4.2 Method B

If crack saturation cannot be detected, tensile test shall be performed with unloading/reloading cycles with increasing force amplitude. The area or the width of the hysteresis loops is directly related to the interfacial frictional shear stress (see Figure 2).



Key

X Displacement (mm)
Y Force (N)
1 reloading
2 unloading

Figure 2 – Schematic diagram showing loading-unloading cycles (hysteresis loops) obtained during a tensile test (Method B)

5 Significance and use

Ceramic matrix composites display non-brittle behaviour under tensile loading conditions only when the fibre/matrix bond is carefully designed. It is essential that the fibre matrix bond is not too strong, which would cause the composite to be brittle. It should also not be too weak, which would cause the composite to be unable to withstand high stresses. Interfaces must exhibit a certain resistance to cracking to allow, firstly, matrix crack arrest and damage tolerance, and secondly, load transfers from the fibre to the matrix. Characteristics of fibre/matrix interfaces are therefore of primary importance in composite engineering, in composite evaluation and in prediction of behaviour and performance.

A mini-composite is a unidirectional composite reinforced with a bundle of parallel fibres. Mini-composites are a simplification of composites. They contain the basic constituents of composites and their response under load is not obscured by texture effects. They are thus used in the investigation of microstructure-property relationships in textile composites and in the determination of interface characteristics.

The important characteristic in the mechanical behaviour of composites is the interfacial frictional shear stress. It measures the ability of an interface to arrest the matrix cracks, and then to transfer stresses from the fibre to the matrix. High interface shear stresses denote efficient load transfers; they reflect the presence of short debond cracks which is indicative of a strong fibre matrix bond. On the contrary, low interface shear stresses denote poor load transfer; they reflect the presence of long debond cracks which is indicative of a weak fibre matrix bond.