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SIST-TS CEN/TS 1159-4:2005

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Advanced technical ceramics - Ceramic composites - Thermophysical properties - Part 4: Determination of thermal conductivity

Hochleistungskeramik - Keramische Verbundwerkstoffe - Thermophysikalische Eigenschaften - Teil 4: Bestimmung der Wärmeleitfähigkeit

Céramiques techniques avancées - Composites céramiques, propriétés thermophysiques - Partie 4: Détermination de la conductivité thermique

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Advanced technical ceramics - Ceramic composites - Thermophysical properties - Part 4: Determination of thermal conductivity

This Technical Specification (CEN/TS) was approved by CEN on 13 July 2001 for provisional application.

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Foreword

This document CEN/TS 1159-4:2004 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of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by January 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: 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.

EN 1159 *Advanced technical ceramics — Ceramic composites. Thermophysical properties* consists of four parts:

— Part 1: *Determination of thermal expansion*;

— Part 2: *Determination of thermal diffusivity*;

— Part 3: *Determination of specific heat capacity*;

— Part 4*: Determination of thermal conductivity*.

Part 4 is a Technical Specification.

Introduction

Statement on patent use

Attention is drawn to the fact that compliance with this document may involve the use of a patented process, which is the "Process for determining the thermal conductivity of a material at high temperature and conductimeter for implementation of this process", given in this document.

CEN takes no position concerning the evidence, validity and scope of this patent right. The holder of the patent has provided a statement concerning use of the patented process. The holder of this patent right has assured CEN that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with the applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with CEN. Further information may be obtained from:

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. CEN shall not be held responsible for identifying any or all such patent rights.

1 Scope

This document describes a method for the determination of the thermal conductivity of ceramic matrix composites with continuous fibre reinforcement. This method applies to all ceramic matrix composites with a fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional (xD, with $2 < x \leq 3$) as defined in ENV 13233, submitted to a heat flux along one principal axis of anisotropy.

The experimental conditions are such that the material behaves in an homogeneous manner for each of its axis of anisotropy and that the heat transfer occurs only by thermal conduction. The method is applicable to materials which are physically and chemically stable during the measurement.

Contrary to other methods of direct measurement which permit only to determine a value of the thermal conductivity averaged over an interval of temperature, the method described in this document, based on an adequate exploitation of the temperature record, allows to determine with a good accuracy the thermal conductivity at a defined temperature. This is more interesting since the variation of the thermal conductivity with the temperature is non-linear, which is generally the case for CMC's.

NOTE It is also possible to calculate the conductivity of CMC's by an indirect method using the following equation:

$$\lambda = a \times p_b \times C_p$$

where

λ is the thermal conductivity;

a is the thermal diffusivity;

p_b is the bulk density;

C_p is the specific heat capacity.

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.

ENV 13233, *Advanced technical ceramics —— Ceramic composites — Notations and symbols*

ISO 3611, *Micrometer callipers for external measurements*

3 Terms and definitions

For the purposes of this document, the terms and definition and symbols given in ENV 13233 and the following apply.

3.1
heat flow, Φ
quantity of heat transferred per unit time

3.2
density of heat flow, ϕ
heat flow per unit area

3.3
representative volume element
minimum volume that is representative of the material considered

3.4
temperature of the hot face, T_h
temperature of the face designated the hot face in Figures 1 and 2

3.5
temperature of the cold face, T_c
temperature of the face designated the cold face in Figures 1 and 2

3.6
temperature of the internal wall, T_{inf}
temperature of the wall designated the internal wall in Figure 4

3.7
temperature gradient, $\Delta T/h$
ratio of the temperature difference $\Delta T = T_h - T_c$ between the two parallel faces of the test specimen to the distance between the two faces, h

3.8
thermal conductivity, λ
ratio of the density of heat flow to the temperature gradient

4 Significance and use

Methods of measurement of the thermal conductivity (either standardised or not) are in the majority dedicated to the characterisation of insulating materials with λ values lower than or equal to 1 $W.m^{-1}.K^{-1}$. Indeed, a principal feature of all direct methods of determination of the thermal conductivity consists in creating a thermal gradient in the test specimen, which explains why such methods are successful when used with insulating materials.

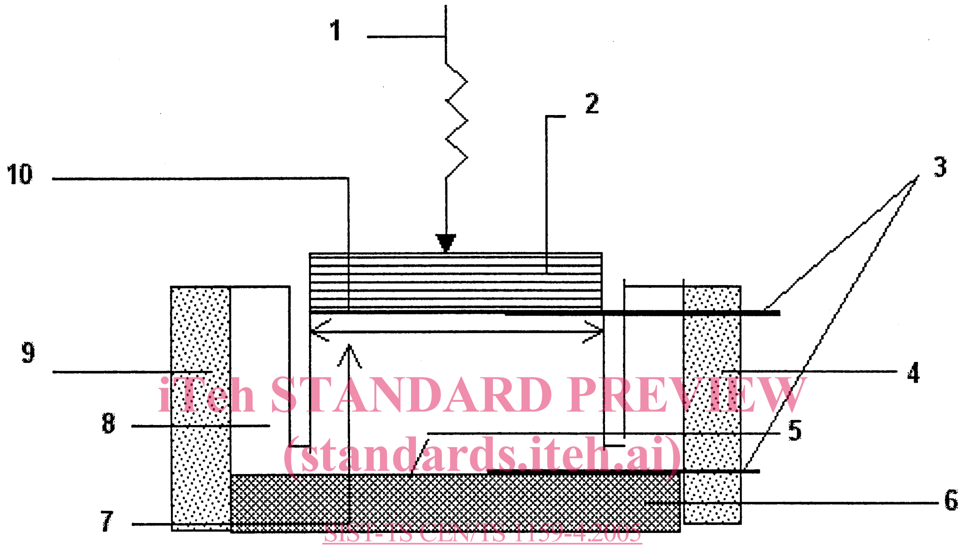
Ceramic matrix composites however, have values of thermal conductivity at low and moderate temperatures in the range of 15 $W.m^{-1}.K^{-1}$ to 100 $W.m^{-1}.K^{-1}$. These values decrease with increasing temperature, but still remain relatively high. This behaviour would require the use of very thick test specimens, in order to achieve a sufficient thermal gradient, a requirement which cannot usually be met. In this case an indirect method such as measurement of the thermal diffusivity, should be used.

5 Principle

The variation of the thermal conductivity of the CMC's with temperature is generally non linear over the range of temperature currently considered.

This document describes a method for the determination of the thermal conductivity within an increment of temperature assuming that the thermal conductivity is linear within this increment. This increment depends upon the material tested. In the first instance it will be set at a value of 100 °C.

The front face (hot face) of a test specimen is exposed to a uniformly distributed temperature T_h using a heating plate. After the system reaches equilibrium, the temperature T_c of the rear face (cold face) is measured as well as the heat flow at this face (see Figures 1 and 2). In order to achieve good conditions of thermal insulation of the lateral faces, it is recommended to use a "guarded test specimen" as depicted in Figures 1 and 2.



Key

1 Tool to secure good contact between the test specimen, the heat-flow measurement system and the heating plate
2 Heat-flow measurement system
3 Thermocouples
4 Lateral insulation
5 Hot face, T_h
6 Heating plate
7 Area of heat transfer
8 Guarded test specimen
9 Lateral insulation
10 Cold face, T_c

Figure 1 — General arrangement of the apparatus for measurement of the temperature on the two faces by thermocouples