Operating Instructions – Laboratory 2

EXAMINATION OF BENDING STRENGTH AND FRACTURE TOUGHNESS

1. BENDING STRENGTH TEST

The aim of the examination is to determine 3-point bending strength of the ceramic, metallic and composite materials (Fig.1).

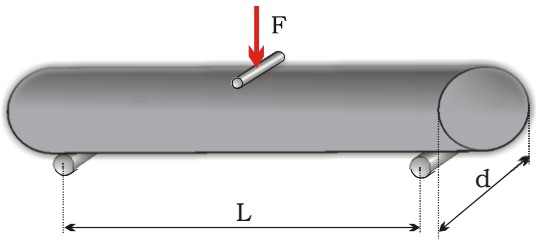

Fig. 1.

During the test a value of force (F) which causes failure of the material (decohesion) is recorded. That value, as well as knowledge of the sample dimensions and some settings of a testing machine allow to determine bending strength of the material (1).

$$\sigma = \frac{F \cdot L}{4W_x} \quad [\mathrm{MPa}] \tag{1}$$

Where:

W_x- section modulus related to the sample shape

In case of rod like shape: $W_x = \frac{\pi d^3}{32}$

d – rod diameter [mm];
F – minimal force causing sample decohesion [N];
L – testing machine support span [mm]

Additional aim of the examination is a presentation of different behaviour of ceramic, metallic and composite materials undergoing 3-point bending.

2. Fracture toughness (K_{Ic}) testing

In case of ceramics there are two methods of determination of K_{Ic}. First of them is Evans' method, which consists of determination of force causing a notched beam fracture during 3-point bending test. The second one requires that the length of the cracks formed in the corners of the Vickers indenter imprint and its diagonal are measured. The method is based on assumption, that length of the cracks coming out from corners of the Vickers imprint is related to fracture toughness (K_{Ic}) of a material. The cracks configuration depends on the material and a force value. For many ceramics the cracks conform to Palmquist's ones (Fig.2).

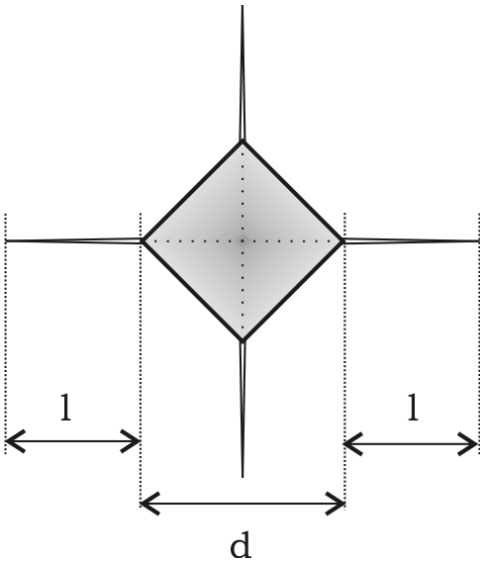

Fig. 2.

When it comes to Palmqvist's cracks the 0.25<l/0.5d<2.5 condition should be fulfilled. If so, fracture toughness expressed by the value of critical stress concentration coefficient K_{Ic}, may be evaluated using Niihara's equation (2).

$$K_{Ic} = 0,018 \cdot H^{0,6} \cdot E^{0,4} \cdot 0,5d \cdot l^{-0,5} \quad [\mathrm{MPa} \cdot \mathrm{m}^{0,5}] \tag{2}$$

where:
H-Vicjers hardness [MPa];
E – Young's modulus {MPa];
d – diagonal length of Vickers imprint [m];
l – average length of the cracks [m];

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