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22. New Technical Solutions in the Technology of Mineral Fibers and Products Based on Them

EVALUATION OF THE CRACK RESISTANCE AND CRACK SENSITIVITY OF REFRACTORIES

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Crack resistance is among the important mechanical properties of refractories, determining to a significant degree their heat resistance* [1, 2]. One measure of crack resistance is the critical stress intensity factor $K_{IC}$ in MN/m$^{3/2}$, which is normally determined by bend testing of rectangular cross-section specimens with an artificially created crack (or thin saw cut) with a depth of about half of the specimen height [3, 5]. In this case

$$K_{IC} = \frac{6M_{bcr}}{bh^2} a^{1/2} Y = \frac{3P_{cr} L}{2bh^2} a^{1/2} Y,$$  (1)

where $M_{bcr}$ and $P_{cr}$ are the failure value of the bending moment in MN·m and the load in MN, respectively; $b$ and $H$ are the width and height of the specimen cross section in m; $a$ is the crack depth in m, $L$ is the distance from the supports to the point of application of the load in m, and $Y$ is a factor dependent upon the type and parameters of the loading method [1, 4].

In investigations of crack resistance the question of the influence of a crack on the supporting capacity of the "active" cross section of the specimen is frequently encountered. Essentially the degree of this influence reflects the crack sensitivity of the material. To determine it, the failure load of a specimen with a crack must be compared with the failure load of a normal specimen, with the condition that the dimensions, form, and orientation of

Fig. 1. Plan of bending of a specimen in determination of crack resistance (I) and strength (II).

the "active" cross section of the specimen with a crack coincide with the same parameters of the cross section of a normal specimen. It is most convenient to make such a comparison in studying the failure of specimens under the action of a bending moment (Fig. 1). Then the measure of crack sensitivity may be the value

\[ K_{cr} = \frac{M_{bc}}{M_b}, \]  

(2)

where \( M_{bc} \) and \( M_b \) are the failure values of the bending moments in loading of a specimen with a crack (Fig. 1, I) and of a normal specimen (Fig. 1, II), respectively, in MN·m. The value of \( K_{cr} \) is called the coefficient of crack resistance and the greater \( K_{cr} \) the less the crack sensitivity of materials.

In order to express \( K_{cr} \) through generally used parameters of the material we transform Eq. (1), having multiplied its numerator and denominator by the value \( 1 - (a/H) \). Then we obtain

\[ K_{tc} = \frac{4M_{bc}Y_h}{bh^{3/2}Y_c} = \frac{P_{c}L}{bh^{3/2}Y_c}, \]  

(3)

where \( h \) is the height of the "active" cross section of the specimen in m, \( Y_h = 1.5a^3/2(1-a) \) is the relative depth of the crack, and \( a = a/H \).

Calculations of the value of \( Y_h \) showed that in pure (four-point) bending in the range of the values most widely used in practice of \( \alpha = 0.47-0.53 \) the value of \( Y_h = 0.993 \pm 0.003 \), that is practically unchanged in relation to \( a \). Therefore with an accuracy of \( \pm 0.3\% \) Eq. (3) may be represented in the following form:

\[ K_{tc} = \frac{3.97M_{bc}}{bh^{3/2}} = \frac{0.993P_{c}L}{bh^{3/2}}. \]  

(4)

In this area of \( \alpha \) the relationship obtained is close to the expression established in [5] by the method of collocation calibration.

In three-point bending the value of \( Y_h \) also changes little in relation to the values of \( \alpha \) and \( \lambda = L'/H \) (\( L' \) is the distance between the supports) influencing it. For example, with \( \alpha = 0.47-0.53 \) and \( \lambda = 4-5 \), \( Y_h = 0.94 \pm 0.009 \). Therefore with an accuracy of \( \pm 1\% \) being completely sufficient for practical purposes we may write

\[ K_{tc} = \frac{0.94P_{c}L}{bh^{3/2}}. \]  

(5)

Next, having expressed the value of \( M_{bc} \) from Eq. (4) and the value of \( M_b \) from the generally known equation of the resistance of materials and having substituted them in Eq. (2), we obtain:

\[ K_{cr} = 1.51 \frac{K_{tc}}{\sigma_b h^{1/2}}, \]  

(6)

where \( \sigma_b \) is the bend strength in MPa.