DETERMINATION OF GEOMETRY-INDEPENDENT FRACTURE MECHANICAL PARAMETERS OF POLYMERS

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REQUIREMENTS ON SPECIMEN THICKNESS USING J-INTEGRAL CONCEPT

For the determination of toughness properties of polymer materials during impact loading the instrumented Charpy impact test has been used (1-3).

Experimental results and FEM-simulation showed that for assessing the toughness of polymer materials it is advantageous to use J-integral approximations of Merkle and Corton (4) and Sumpter and Turner (5). The evaluation method according to Sumpter and Turner can be defined from the equation (1) for 0 < a/W < 1.

\[ J_{Ic} = \frac{A_e}{B (W-a)} + \frac{A_p}{B (W-a)} \]  

(1)

The J-integral values determined experimentally, are geometry-independent if they satisfy the criterion (2), where \( \varepsilon \) is a specific constant of the material.

\[ B, (W-a), a > \varepsilon \frac{J_{Ic}}{R_e} \]  

(2)

Experimental values of \( \varepsilon \) (they lie between 10 and 90) were investigated for influence of specimen thickness (2), see fig. 1. The knowledge of the general -J- connection permits the evaluation of the respective specimen thickness.

The advantage of determination of dynamical fracture mechanical values is that geometry-independent values can be obtained with small specimen thickness. In consideration of experimental conditions (2), B = 4 mm was chosen.

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MODEL FOR DETERMINING THE COD

Besides the J-integral concept, the COD-concept has been used especially to describe the brittleness of anorganic filled polymers. The formation of a quasi-static tension crack is a prerequisite for investigating critical crack opening displacements. On the basis of the plastic-hinge model the critical crack opening displacement can be investigated with the help of eqn. (3). Prior to the investigation it is necessary to separate the maximum deflection \( f_M \) into a notch-portion \( f_k \) and a bend-portion \( f_b \).

\[
\delta_{dk} = \frac{1}{n} (W-a)^{n-1} \frac{4 f_k}{s}
\]

In (2) it has been shown for several materials that \( \delta_{dk} \) is independent of \( a/W \) ratio, when \( B = 4 \text{ mm} \) and \( a/W > 0.25 \). The critical crack opening displacements are geometry-independent, when the criterion (4) is satisfied.

\[
B, a \geq \frac{3}{5} \delta_{dk}
\]

Fig. 2 shows, that \( \delta \) depends on material and that a considerable overestimation of the necessary minimum specimen dimension is possible, if the evaluation of the necessary notch depth respectively specimen thickness is unknown.

SYMBOLS USED

- \( A_{e,p} \) = deformation energy (elastic, plastic part) (mm)
- \( a \) = notch depth (mm)
- \( B \) = specimen thickness (mm)
- \( J_{Id} \) = J-integral value (N/mm)
- \( n \) = rotation factor
- \( s \) = distance between supports (mm)
- \( W_r \) = specimen width (mm)
- \( \delta_{Id} \) = critical crack opening displacement (mm)
- \( \gamma_{e,p} \) = corrective functions

REFERENCES


![Figure 1](image1)

Figure 1 Dependence of $\varepsilon$ on $J$-integral value.

![Figure 2](image2)

Figure 2 Dependence of $\varepsilon$ on $\delta_{dk}$