CORRELATION OF FRACTURE MECHANICS PARAMETERS WITH CHARPY-ENERGY BASED ON STATISTICAL EVALUATION

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By means of test results it could be shown, that acorrelation exists between the ductile fracture mechanics characteristic J-integral at initiation J_i and the upper sheet of the notched bar impact energy. Owing to a statistical evaluation and with the aid of the relationships indicated, the user can choose the probability with which the value selected is to be situated within the range in question by which the width of the scatter is presupposed.

INTRODUCTION

The methods of elastic-plastic fracture mechanics for the quantification of ductile failure of cracked components have been mastered theoretically to an ever greater extent. The necessary ductile fracture mechanics characteristics can only be determined with sufficient reliability at relatively high cost and are therefore often not available. In the present paper correlations are stated by means of which on a statistic basis the fracture mechanics characteristic values for crack initiation J_i for the upper shelf of notched bar impact energy can be evaluated.

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STATISTICAL DETERMINATION OF MATERIAL SCATTER

The method of determining the fracture mechanics material characteristic J-integral at initiation, J_i, is based on stipulation of the stretched zone Δa_{st}. This represents the region of extreme plastic deformation at the crack tip prior to stable crack growth. The principle of the method is that subsequent to blunting, the stretched zone is fully developed and is maintained as crack growth continues. At completion of the test the stretched zone can be measured from a vertical projection of the fracture surface in a scanning electron microscope. To reach the value J_i, the point of the J-Δa curve defined as

$$J(\Delta a_{st}) = J(\Delta a_{tot})$$

must be found. The J-value thus defined is designated as the physical crack initiation characteristic value J_i, Roos and Eisele (1). A fitting or nonparametric test for a normal and log-normal distribuation was carried out by means of the χ^2 test. As the level of significance α a value of 0.05 which is usually applied for this type of problem was chosen, i. e. the J_i values correspond to a standard distribution if the calculated value of estimation $\hat{\chi}^2$ is inferior to the quantile χ^2_α of the level of significance $\alpha = 0.05$ and the degree of freedom of ν. The degree of freedom ν is equal to r - 1- a; a indicates the number of the estimated parameters of the chosen distribution and r stands for the number of subdivisions of the totality of distribution functions to be examined. In the case of a log-normal distribution the $\hat{\chi}^2$ values were all higher than in the case of a normal distribution which means that with the normal distribution the fitting is better. On this basis, the following dependence of the mean value of $\bar{J}_i$ and of the deviation from the mean value on the upper shelf of notched bar impact energy was evaluated, see also Kussmaul and Roos (2):

$$\bar{J}_i + n\sigma = k_1 + k_2\ C_v^2 + k_3\ C_v^3$$

Table 1 contains a summarizing of these coefficients. In figure 1 the curves and the test values are shown.

TALBE 1 - Coefficients of dependence of J_i on upper shelf of notched bar impact energy.

n	$k_1 \cdot 10^{-2}$	$k_2 \cdot 10^{-6}$	$k_3 \cdot 10^{-9}$
1	6873.	8743.	- 11380.
0	4165.	4827.	847.
-1	2796.	589.	19570.

Range of validity:
notched bar impact energy: 30 J to 200 J
yield strength : 350 MPa to 1100 MPa
tensile strength : 500 MPa to 1200 MPa

REFERENCES

(1) Roos, E. and Eisele U., J. of Test. and Evaluation, Vol. 16, 1988, pp. 1-11.
(2) Kussmaul, K. and Roos, E., Nucl. Eng. and Design, Vol. 87, 1985, pp. 123-137

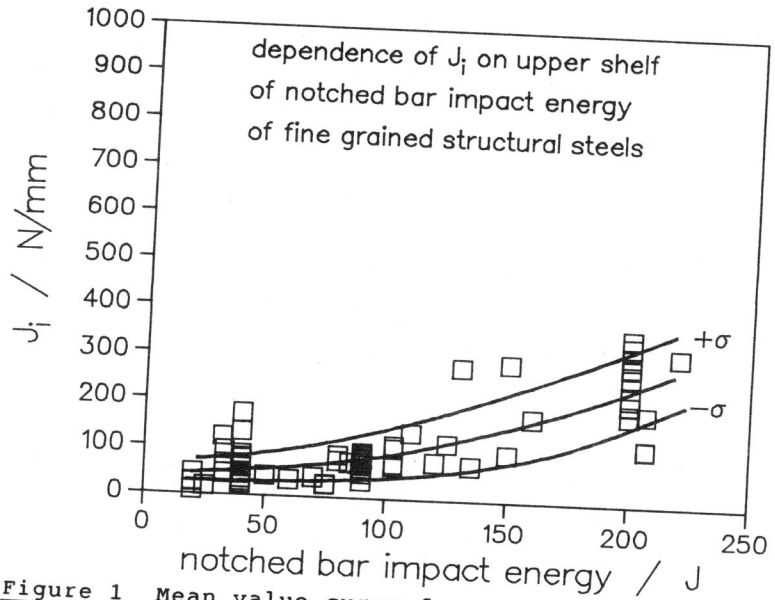

Figure 1 Mean value curve from J_i values and the curves for $J_i \pm \sigma$.