# The Pulsating Tensile Fatigue Behavior of CT - Specimens with Small Notch Root Radius

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## 1) Theoretical considerations

The fatigue strength of notched parts is, in a simplified way, regarded to be in a relatonship with the Hookian stress concentration factor. Comparing two geometrically different notched parts with the same Hookian stress concentration factor, it can be observed in many cases that the fatigue strength differs. These differences are taken into account by considering either the gradient of maximum stress /1/ or the mean value of the stresses near the notch root /2/. For the sharply notched infinite plane with symmetrical hyperbolic notches, elliptic hole /3/ and parabolic notch /4/ it was shown that in case of uniaxial tensile load, the elastic stress field near the notch root can be described by the stress intensity factor $K_I$ and a function $F_{iK}$ which only depends on the coordinates $r, \varphi$ and the notch root radius $\varrho$

$$\tau_{ik} = K_I F_{ik}(r, \varphi, \varrho) \tag{1}$$

where

$$K_I = \sigma \sqrt{a \pi}\, f\left(\frac{a}{b}\right) \tag{2}$$

for finite specimens of the width b and the notch depth a. Thus, the stress intensity factor $K_I$ characterizes the elastic stress field near the notch root of specimens having different shapes but equal notch root radii. Now we assume that, in case of small plastic deformation near the notch root, there exists a well-defined relationship as well between the state of stress in this region and the stress intensity factor.

## 2) Experimental results

For experimental examination of this assumption fatigue tests within the range for pulsating tensile stresses ($\sigma_{min}/\sigma_{max}$ = 0,1) were carried out using 7075-T6 aluminum alloy CT-specimens /5/ (Fig.2) with the thickness d = 20 mm, the width b = 40 mm and the notch root radius $\rho$ = 0,5 mm. The notch depth a was varied and amounted to a = 10 mm, = 15 mm, = 20 mm and = 25 mm. For the four specimens tested the finite element method was used to verify the applicability of equations (1) and (2) and to determine the Hookian stress concentration factor $\alpha_H$.
Fig.1 shows the SN-diagrams for the four types of specimens having the Hookian stress concentration factors of $\alpha_H$ = 4,00; 4,78; 5,62 and 6,71. The ordinate indicates the nominal stress amplitude

$$\sigma_{an} = \frac{P_a}{d(b-a)}\left[\frac{3(b+a)}{b-a}+1\right] \qquad (3)$$

($P_a$ = load amplitude)
The abscissa indicates the number of cycles to failure with 50% probability of failure.
Fig.2 shows the amplitude of the stress intensity factor

$$K_{Ia} = \frac{P_a\sqrt{a}}{bd}\left[29.6 - 185.5\left(\frac{a}{b}\right) + 655.7\left(\frac{a}{b}\right)^2 - 1017\left(\frac{a}{b}\right)^3 + 638.9\left(\frac{a}{b}\right)^4\right] \qquad (4)$$

according to /5/ instead of the nominal stress amplitude plotted in Fig.1. It can be seen that the test results (Fig.2) show a very small scattering for the four different specimens.
In a more correct way, not the number of cycles to failure N, but the number of cycles N' where the crack growth towards the end of the fatigue test is unaffected by the stress field of the notch, should be considered by comparing the test results of the four different specimens. In order to get some information on the crack growth during the tests the displacement across the notch at the specimen edges (point A, Fig.2) was recorded. The evaluation has yet shown, that the difference between N and N' is



not essential.

## 3) Summary

It was shown by fatigue tests in the range for pulsating tensile stresses performed with notched specimens of different shape but equal notch root radius that the fatigue behavior can be described by the stress intensity factor. A revision of the method for other notch root radii and other materials is intended.

## 4) References

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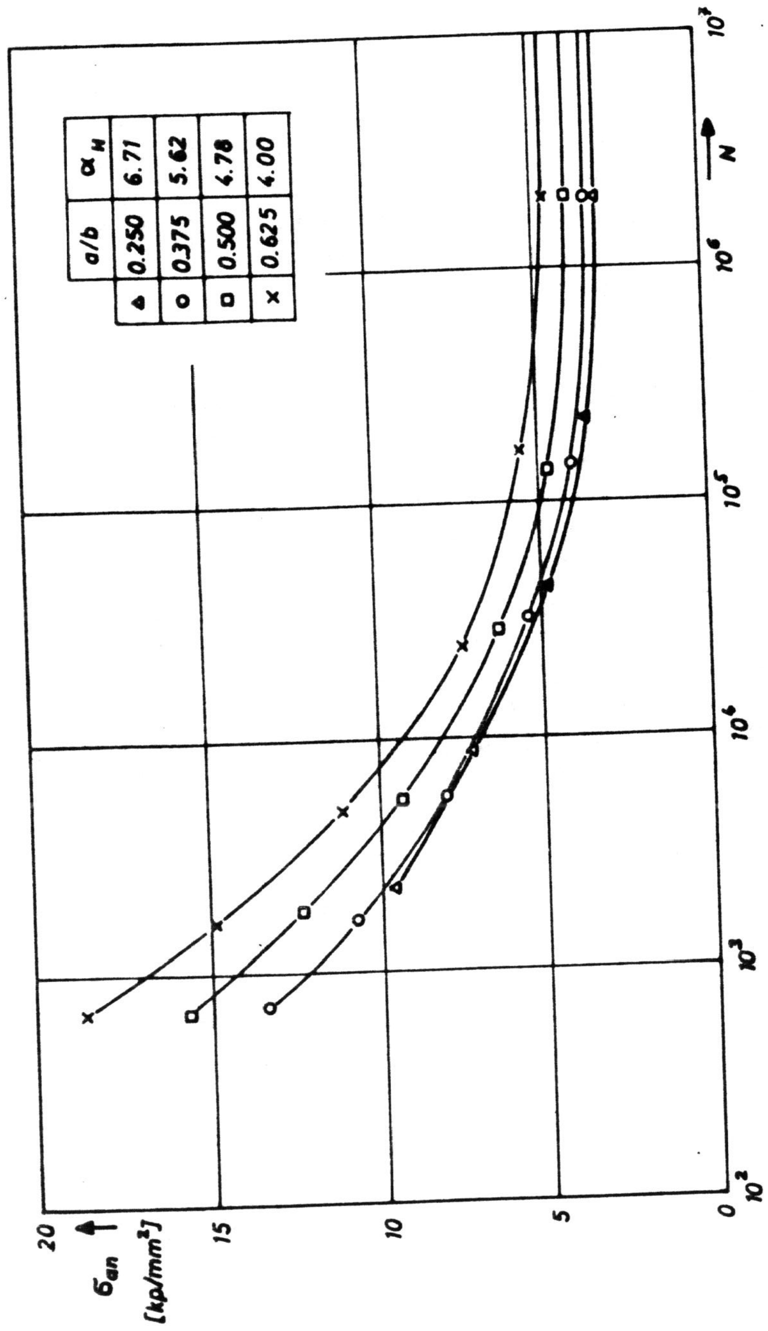
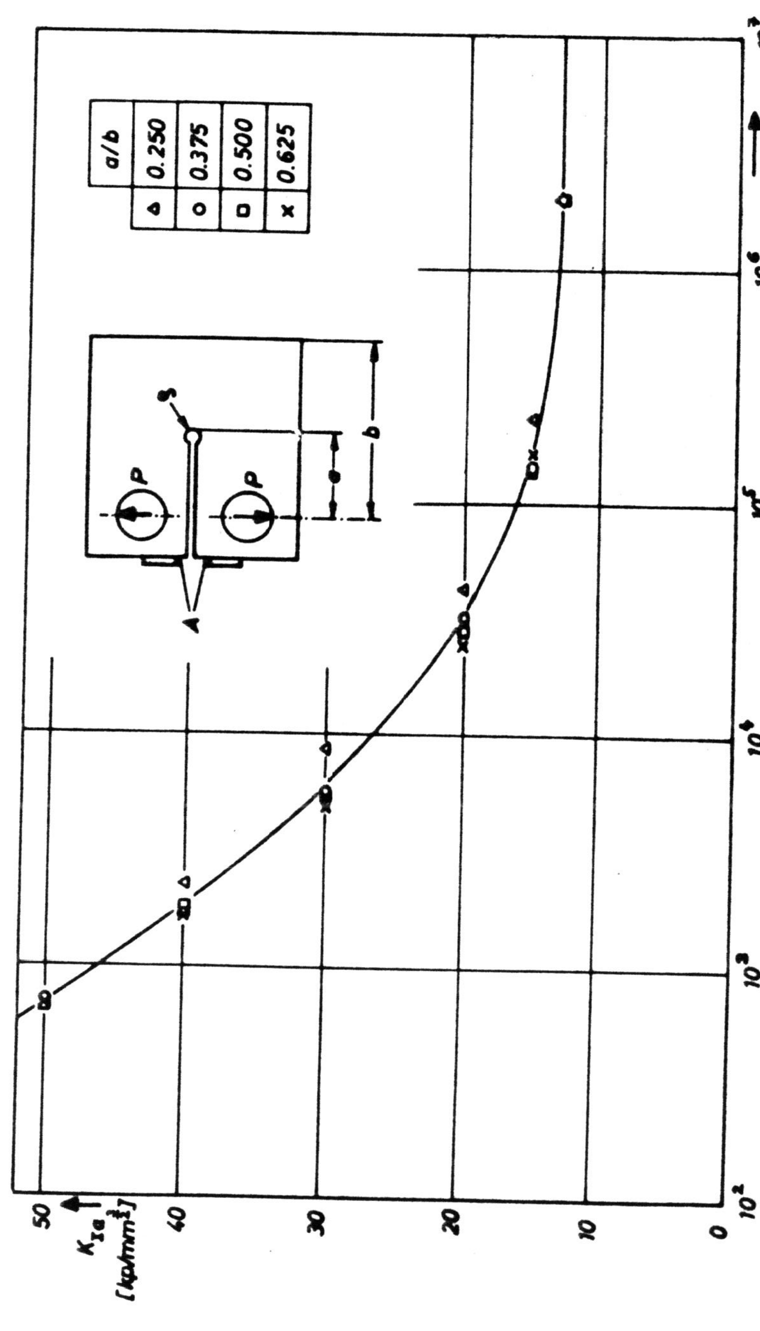


a/b
α_H
Δ 0.250 6.71
o 0.375 5.62
□ 0.500 4.78
x 0.625 4.00
σ_an [kp/mm²]
20
15
10
5
0
N
10²
10³
10⁴
10⁵
10⁶
10⁷


Fig. 1





a/b
Δ 0.250
o 0.375
□ 0.500
x 0.625
P
P
S
A
a
b
K_Ia [kp/mm^3/2]
50
40
30
20
10
0
N
10²
10³
10⁴
10⁵
10⁶
10⁷


Fig. 2