MEASUREMENTS OF CRACK GROWTH BY MEANS OF CONTINUOUS SOUND DURING INSTRUMENTAL CHARPY-TEST

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INTRODUCTION

Determination of dynamic fracture mechanical parameters from measured curves of instrumental Charpy-test necessitates the verification of crack initiation or the correlation between time (deflection) and crack growth. More-specimen methods have been successfully used determining the crack resistance curve by varying the impact energy or limiting specimen bending. Of course, this is subject to a whole series of specimens and their expensive preparation. In addition to the force curves further details about mechanism of crack propagation could be produced by recording high frequency signals, which are directly influenced by the crack growth.

Concerning a method of noise emission measurements by Kalkhof (1) the point of crack initiation could be determined with a reproducibility of about 0.7 µsec. Obviously in this way it is not possible to determine the whole characteristic of crack resistance of tough materials, because plastic deformations are also recorded by noise emission and, consequently, there is no well defined connection to the crack growth.

This approach is meant to measure crack growth via the correspondingly altered ultrasound transmission through the crack plane. Transducers should be designed fitting to specimen's geometry and to crack size. The transducer's support is bound to adapt to the pendulum construction. The sound field is to cut the whole remaining cross-section. Moreover, it is possible to focus the sound beam on the middle of the crack front by means of a cylinder lens.

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MEASUREMENT OF CRACK LENGTH BY MEANS OF CONTINUOUS SOUND

Special angle beam transducers (80°) were designed to measure the effective voltages in transmitter-receiver-operation. They were pressed on the top and on the bottom side of the test specimen in such a way, that the sound beam passes the specimen vertically and touches the middle of the crack front.

A collection of steel test specimens with various fatigue crack lengths were used to measure the corresponding sound amplitude. The uncertainty of 0.5 mm of the crack length may be improved by completing of test collection. Generally, no monotonous calibration curve was found, which shows, that the interference phenomena have an authoritative influence on the sound amplitude. Evidently, interference effects decrease with higher frequencies and values above 2 MHz should be prefered. On the other hand the use of frequencies above 20 MHz is restricted by the damping of ultrasound. Nevertheless the relation between sound amplitude and crack length is unique, because the crack can't but grow versus time. Moreover, trouble signals caused by inertial effects must be locked out by using of a band-pass filter (1850-2150 kHz).

Series of Charpy-tests were carried out with brittle and tough materials. The figure shows a measurement of a warm-pressed steel 10CrMo9.10 with an initial crack length of 2 mm and an impact velocity of 4 m/sec. Due to high toughness and low impact velocity the inertial effects are limited and are placed in front of the window shown in the figure. The values of crack lengths were taken from the calibration curve of sound amplitude by the frequency of 2 MHz. All results must be checked by means of crack-stop tests, whereby crack lengths are measured optically.

REFERENCES

(1) Kalkhof, D., Materialprüfung, Vol. 28, No. 9, 1986, pp. 267-271

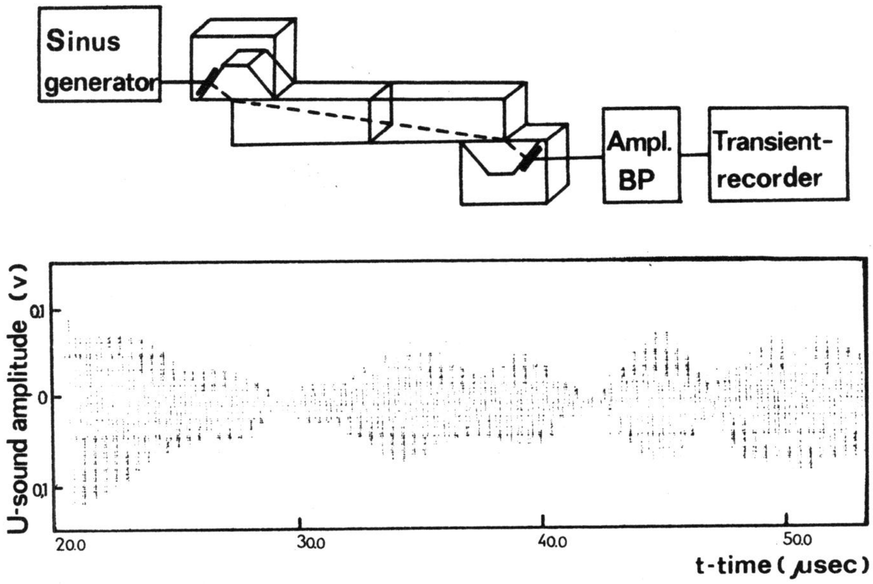

Figure 1. Measurement of ultrasound signal during instrumental Charpy-Test with steel specimens

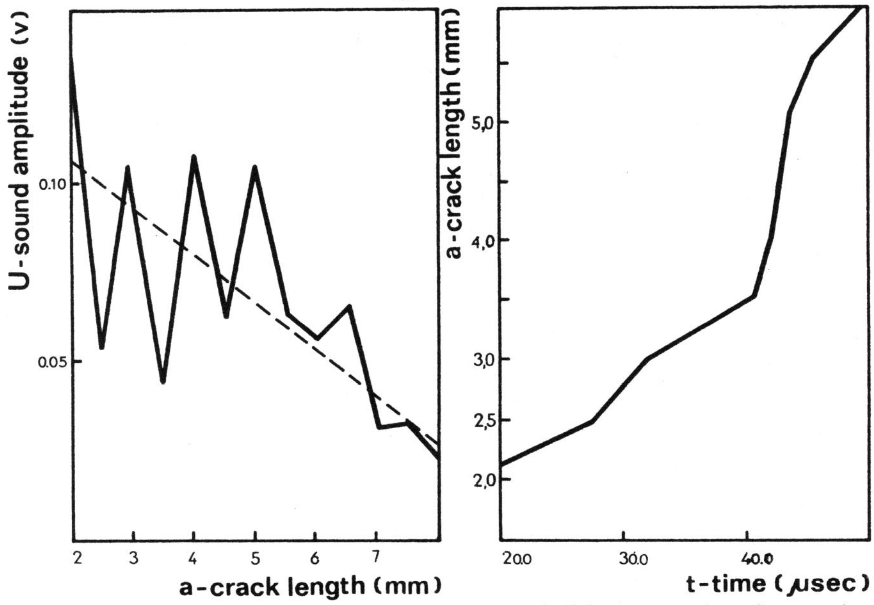

Figure 2. Calibration curve and unfolded graph of crack length via the correspondingly time