FRACTURE PROPERTIES EVALUATION FROM DYNAMIC TENSILE TESTING

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The measurement of dynamic fracture properties -specially on irradiated materials- is a difficult task. New local approach have been elaborated by using smooth and notched tensile bars to measure dynamic Absorbed Specific Fracture Energy and calculate fracture toughness properties of irradiated materials. For dynamic tensile testing a 300 J instrumented impact machine were modified.

INTRODUCTION

It occurs often during the testing of elastic-plastic materials that specimen size requirements cannot be compiled with (e.g. in testing of irradiated materials), and if yes the values measured on large size specimens give average material properties over the specimen thickness. To evaluate the safety of a pressurized structure different local approaches based on volumetric energy criteria are promising ways to solve these problems. One possibility is the use of dynamic tensile testing. Dynamic tensile testing has the advantage that all of the three state factors: temperature, volumetric stress distribution and strain rate can be chosen nearly freely.

DYNAMIC TENSILE TESTING

For such measurements we implemented an instrumented Charpy machine for dynamic tensile testing .The dynamic tensile specimens can be cut very cheaply from small material pieces, even from the remnants of broken Charpy specimens.

By changing the length of the specimen the strain rate can be altered over a wide range without changing the speed of the hammer. If smooth and differently notched round tensile bars are utilized

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different volumetric stress distributions can be selected.
A 300 J capacity impact tester fitted with a load and displacement transducer was directly connected with a transient recorder, into which original unfiltered signals were transmitted. After the measurements the curves were transmitted to a microcomputer where a simple averaging algorithm was used to separate the noise from the signals. The passing frequency of the filtering software can be selected in accordance with the measured transient.

The load-time curve can be converted mathematically into a load-displacement diagram by applying the theory of conservation of momentum. A software has been elaborated for this calculation. As the area of the load-displacement curve has to indicate the energy measured by the Charpy machine, the microcomputer can calibrate every curve dynamically.

FRACTURE PROPERTIES EVALUATION BASED ON ASFE

From the dynamic tensile curve the dynamic yield stress, ultimate stress, and absorbed specific fracture energy (ASFE) can be calculated (1,2):

$$W_c = \int_0^{\varepsilon_f} R' d\varepsilon \qquad (1)$$

Using different measurement temperatures a transition temperature can be indicated. The ASFE transition temperature is different from the Charpy transition temperature, but the transition temperature increase measured with different methods can be compared.

From the ASFE measurements the Critical Values of Strain Energy Density were calculated succesfully in several cases, specially on aluminium materials.

Czoboly and Radon (3) determined the stretched zone dimensions L_o from the deformation of notched specimens, extrapolating to an infinitely sharp notch (R=0) representing a crack and calculated J_{1c} from W_c by the following formula:

$$J_c = W_c x L_o \qquad (2)$$

IRRADIATED FRACTURE TOUGHNESS EVALUATION

A practical use of this method is the calculation of K_{1c} values of the irradiated materials (4). K_{1c} should be measured on unirradiated specimens fulfilling standard requirements, the irradiated value can be calculated by the modification of equ. (2):

$$K_{1c(irrad)} = K_{1c} x (W_c x L_o)_{(irrad)} / (W_c x L_o) \qquad (3)$$

On small size specimens and specially on irradiated materials the measured L_o values are widely scattered due to the technical problems of such a measurements; a method to avoid this was developed. Since the necking of the sharply notched tensile specimens is small, the total energy divided by the area of the fractured surface gives an acceptable surface fracture energy value. The values of the total absorbed energy measured on differently notched round tensile bars can be extrapolated to aninfinitely sharp notch representing a crack and this value divided by the fracture area gives the notched specific surface energy of fracture. Due to the strain distribution it is not an exact fracture toughness value, but the ratio of the irradiated and unirradiated values can be used for calculating irradiated K_{1c} values by the modified form of formula (3):

$$K_{1c(irrad)}=(K_{1c} x W_{t(irrad)})/W_t \qquad (4)$$

This method seeems to be more reliable than the K_{1c} reference curve correction by Charpy transition shift.

SYMBOLS USED

ε = true strain

R' =true stress (N/mm^2)

W_c = Absorbed Specific Fracture Energy (ASFE) (J/cm^3)

W_c = specified total absorbed energy (J/cm^2)

K_{1c} = fracture toughness ($MPam^{-0.5}$)

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