EVALUATION OF STATIC AND DYNAMIC R CURVE USING DC POTENTIAL DROP SINGLE SPECIMEN METHOD

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Static and dynamic R-curves are evaluated using direct current potential drop (DCPD) single specimen method. Previosly, tests for accurate calibration of (Δa-PD) dependence and optimizing of test parameters had been performed.

Evaluated static R-curve exhibits a good agreement with R-curve obtained by ASTM-E-813 standard test method. Dynamic R-curves show increased values compared to the static R-curve, and that is in good agreement with results obtained by other methods for dynamic R-curve evaluation.

The agreement obtained in static standard and developed dynamic method offers the possibility for the application of proposed method for evaluation of dynamic R-curve.

INTRODUCTION

Current requirements of materials specification include quantification of their resistance to crack initiation and growth in static and dynamic loading conditions.The resistance to initiation and propagation of ductile cracks can be quantified by resistant curve (R-curve). Fracture mechanics testing techniques are developed and number of standard test methods for static loading conditions are in general use. One of them is a single specimen method for static R-curve according to ASTM-E-1152. For the evaluation of dynamic R-curve no standard procedures has been prescribed, but some of methods have already been proposed. One of them, based on direct current potential drop (DCPD) method, is described in this paper.

This paper presents method of evaluating static and dynamic R-curve which is based on monitoring of crack gowth by current potential drop during test.

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STATIC AND DYNAMIC R-CURVES EXPERIMENTS

Direct current potential drop (DCPD) is commonly accepted as a method of crack length measure in fatigue and creep crack growth tests and for detection of crack initiation in fracture mechanics test methods (1, 2).

Recently published results (3,4) indicated the applicability of DCPD, established in single specimen tests, for R-curve evaluation, if a suitable calibration Δa-PD could be developed. Single specimen technique with applied constant direct current (DC) allows the evaluation of crack length increase (Δa) by measurement of potential drop (PD) across the specimen.

Material and test specimens

Standard precracked Charpy V specimens with crack length a /specimen width W ratio/ of 0.45-0.55 were tested. The specimens were produced of Yugoslav HSLA quenched and tempered steel, with properties presented in Table 1 and 2.

TABLE 1 - Composition of tested HSLA Steel

C (%)	Mn (%)	Si (%)	Ni (%)	Cr (%)	Mo (%)	P (%)	S (%)	V (%)	Al (%)
0.1	0.25	0.2	3.1	1.24	0.29	0.009	0.018	0.05	0.08

TABLE 2 - Properties of HSLA Steel (Quenched and Tempered)

Yeld stress	Ultimate tensile strength	Elongation	Contraction	Charpy Energy at	
				20°C	-100°C
(MPa)	(MPa)	(%)	(%)	(J)	(J)
780	820	19	68	126	93

Equipment

Specimens had been fatigue precracked on resonant high frequency fatigue machine Amsler, 100 kN. Tests were performed using DC power supply Type HP 6260B (max 120 A, 12 V). Oscilloscope "Tektronix" 5103 with amplifier was used for PD measuring. Input and output lead connections are indicated in Figure 1. Static tests were performed in servo hydraulic testing machine "Instron" M 8032/250 kN. Impact test were performed on instrumented Charpy impact machine "TINIUS OLSEN", with energy 358 J at 5.11 ms^{-1} .

For dynamic tests a waveform analyzer Philips PM 3360 coupled with HP87XM computer had been used, for storing measured data of applied load, energy and PD in time. Data acquisition had been performed with the software, developed for this purpose(5).

RESULTS

The results of previously performed tests were used for accurate calibration of Δa-PD dependence curve, and for the optimization of test parameters (4,5,6). Calibration (Figure 2) had been verified by multi-specimen crack arrest tests, according to recorded load, PD and displacement. Ductile crack length had been measured on broken specimens after heat-tinting as presented in Figure 2 (5).

Static test

Typical plots of load and PD versus displacement for static test are presented in Figure 3. The pairs of load-PD data are taken from the same plot, as indicated in Figure 3. J-integral is evaluated according to the

$$J = \frac{U}{B(W-a)}$$

for applied energy U, specimen thickness B, width W and crack length a.

Using calibration curve (Figure 2), R-curves are designed for series of samples, Figure 4. In addition, R-curve, obtained by multispecimen method according to ASTM-E-813 is presented in Figure 4. The J_{Ic} value obtained according to ASTM -E -813 by multispecimen method is 207 kJ/m^2 , and the value obtained by DCPD single specimen method are ranged between 189-202 kJ/m^2.

Dynamic tests

Typical plots of load, energy and PD versus time for dynamic tests are presented in Figure 5. Dynamic R-curves shows are shifted to higher J values compared to static R-curve, Figure 6 (5,7). This result is in a good agreement with result obtained by other methods for steel of similar quality (6).

CONSLUSION

Evaluation of static and dynamic R-curves using DCPD single specimen method is possible if based on suitable Δa-PD calibration.

Static curves and J_{Ic} values obtained from DCPD procedure are in good agreement with multispecimen data.

Proposed method has good perspective as dynamic fracture mechanics testing techniques.

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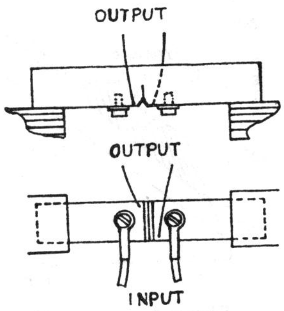

Figure 1 DCPD Charpy specimen

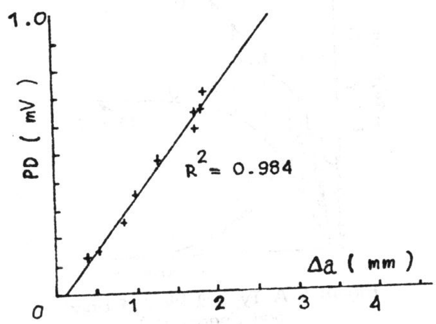

Figure 2 PD versus Crack Length Calibration

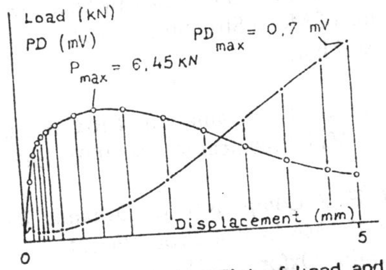

Figure 3 A Typical Plot of Load and PD against displacement (static test)

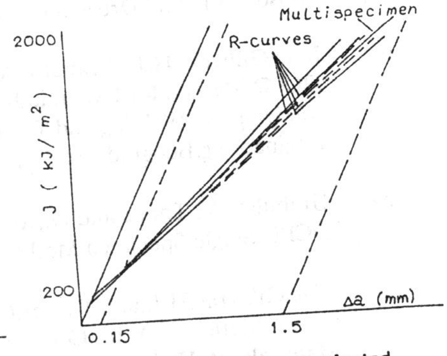

Figure 4 Static R-curves evaluated using DCPD test and according to ASTM E-813 (multispecimen)

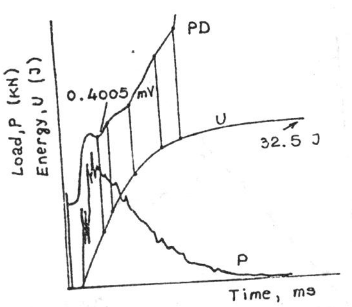

Figure 5 A Typical Plot of Load and Energy (U) against Time (dynamic test)

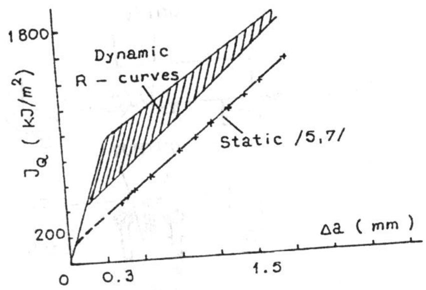

Figure 6 Dynamic R-curves evaluated using DCPD test