Optimization of Crack Length Measurement by DCPD in DCB Specimens

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ABSTRACT

The optimization of four-probe DCPD crack length measurement has been carried out experimentally for the NACE standard double cantilever beam (DCB) specimen with side grooves, for which the solution based on available analytical or numerical approaches remains difficult due to specimen geometry. The optimum lead positions give good combined sensitivities to both absolute output and relative DCPD ratio, as well as a good linear correlation with crack length. A DCB analogue with uniform thickness has also been further tested. The results show that the principles of the optimization hold for DCB specimens with or without side grooves. Technical points related to the four-probe DCPD method are discussed.

INTRODUCTION

The double cantilever beam (DCB) specimen has been used extensively in the research and development of structural steels for oil/gas industrial applications; it is the only type of fracture mechanics-based specimen specified, so far, by the NACE standard (NACE TM0177-90) to test the resistance of metals to sulphide stress corrosion cracking (SSCC). Although the specimen was intended, mainly, to determine the threshold stress intensity factor, \( K_{\text{Isc}} \), and the existing standards (NACE TM0177-90, ISO7539:1989) do not address the measurement of crack growth rate, it has been realized that the monitoring of its crack growth is advantageous for the following reasons:

- To ensure that crack propagation has ceased, and hence the reliability of the related threshold value.
- The test duration necessary to obtain \( K_{\text{Isc}} \) using DCB specimens is strongly dependent on the metal/environment to be tested. For instance, it can vary from just two weeks for high-strength low-alloy steels (HSLA) in H₂S saturated 5% brine (Heady, 1977, NACE TM0177-90) up to several months for 13%Cr stainless steel in 5% brine containing 20 ppm H₂S (Barker et al., 1993). The stress intensity factor initially applied may also affect the termination time of the test (ISO7539:1989). The test duration given by the NACE standard is empirical; only a minimum test time is suggested for a limited number of metals in the standard solution.

- To characterize the crack behavior.

Very useful information, e.g., \( \frac{da}{dt} \) vs. \( K_1 \), hydrogen delayed cracking and intermittent advance of the crack, etc. (Yu and Brook, 1991; Yu et al., 1994a) can be obtained and used for material selection and life prediction of components.

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KEY WORDS: Crack length measurement, DCB specimen, DCPD, stress corrosion testing.