Practical Use of PCVN Specimens for J-R Fracture Toughness Testing

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1. Introduction

PCVN (pre-cracked Charpy V-notch) specimens are used for J–R fracture toughness evaluation. They are a type of SEB (single-edge bend) specimen that is readily available in most surveillance test programs. The ASTM standard method for J-R fracture toughness testing [1] provides detailed procedures and equations. However, some important guidelines for SEB specimens are lacking, such as a rotational correction method for measured unloading compliance and a detailed procedure for using load-line displacement (LLD) instead of crack mouth opening displacement (CMOD).

This paper revisits the following issues to improve the practical use of PCVN specimens for generating reliable J–R fracture toughness data: 1) consideration of knife-edge gap shrinkage to compensate for rotational effects on measured unloading compliance values; 2) comparison of J–R curves determined by the unloading compliance method and the normalization method; and 3) optimization of the load-line displacement-based procedure to obtain J-R data comparable to those obtained using a COD gage [2,3].

2. Test Methods

J–R tests were performed at room temperature using side-grooved PCVN specimens in accordance with ASTM E1820. CMOD was measured using a COD gage attached to the knife-edge on the front face. Machine stroke displacement was also recorded to evaluate the load-line displacement-based procedure.

The load-displacement data were analyzed using both the unloading compliance method and the normalization method. In addition, to verify the applicability of the simplified normalization procedure, some tests were conducted under monotonic loading conditions without unloading.

3. Results and Discussion

J–R tests were conducted at room temperature following the standard unloading compliance procedure. Load, COD gage, and stroke displacement data were continuously recorded during testing. Some specimens were loaded monotonically without unloading sequences.

The COD gage data were analyzed using both the standard unloading compliance method and the normalization method for comparison, whereas the stroke displacement data were analyzed using the normalization method only.

Fig. 1(a) presents the results obtained from the unloading compliance method and the normalization method. Accurate determination of the normalization J-R curve required precise definition of the origin of the load-displacement record through back-fitting of the initial linear slope. After correcting for physical crack growth, the unloading compliance method yielded results nearly identical to those obtained from the normalization analysis when the same CMOD records were used. Normalization analysis based on load-line displacement also produced comparable results when a plastic η factor of 2.0 was applied.

Fig. 1(b) shows the results from monotonic loading tests, which were analyzed using the normalization method only. In this case, load-line displacement converted from the measured stroke displacement was capable of producing reliable J-R curves comparable to those obtained from CMOD data when a plastic η factor of 2.0 was used.

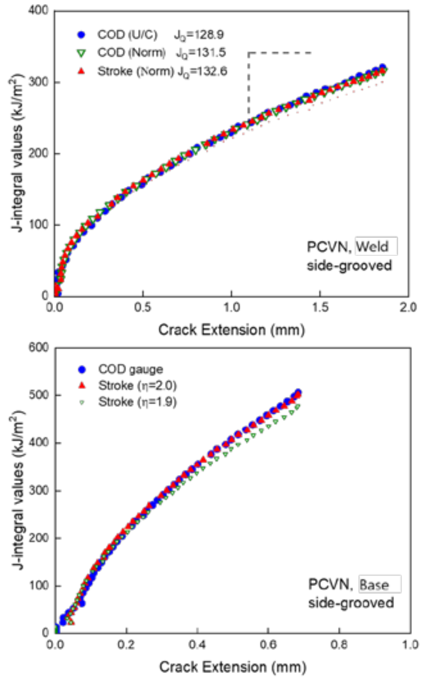

Fig. 1. Comparison of J-R test results determined by different approaches for PCVN specimens

4. Conclusions

This study demonstrates that PCVN specimens can be effectively used for reliable J-R fracture toughness testing with the following considerations:

- A simple rotation correction equation for SEB specimens could be derived by accounting for contraction of the knife-edge spacing due to plastic deformation.
- The normalization method and the unloading compliance method yielded equivalent J-R curve results when properly applied.
- Load-line displacement measured at a remote stroke position could be accurately converted for J-R curve analysis using the normalization method, with a plastic η factor of 2.0 providing better agreement than a current standard value of 1.9.

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