Modified Normalization Method for Dynamic Loading J-R Test using Blunt Notch Specimen

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1. Introduction

J-R test based on elastic plastic fracture mechanics, has been widely used in safety assessment of pressure vessel and pipe in nuclear power plant. DC-potential drop (DCPD) method has been employed by some researchers for use in dynamic loading J-R test to simulate seismic loading effect. But, the method has the significant shortcoming with ferromagnetic materials due to ferro-electric noise. [1~5]

The normalization method which was accepted to American Society for Testing and Materials (ASTM) standard test method in 2001[6], is a very useful method to determine J-R curve under dynamic loading or other difficult conditions, because it does not need any additional equipments or complicate loading sequences like electric current or unloading. But, in the normalization round robin under static loading condition, some unreliable results were shown which are larger deviation and greater J_{Ic}'s than the unloading compliance method.[7] In this study, the source of the large deviation and differences of current normalization procedure was explored, and the modified normalization procedure was developed to improve the reliability.

2. Methods and Results

2.1 Modified Normalization Method

The problems of standard normalization method came from the limited information for normalization curve. In this study, blunt notch specimens were used in order to measure more reliable data for normalization curve because the blunt notch specimen can keep a stationary crack, as shown in the following figure. The deformation characteristics of the blunt notch specimens were examined and then the modified normalization procedure using the blunt notch specimen was proposed.
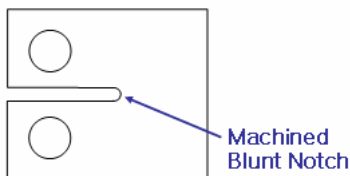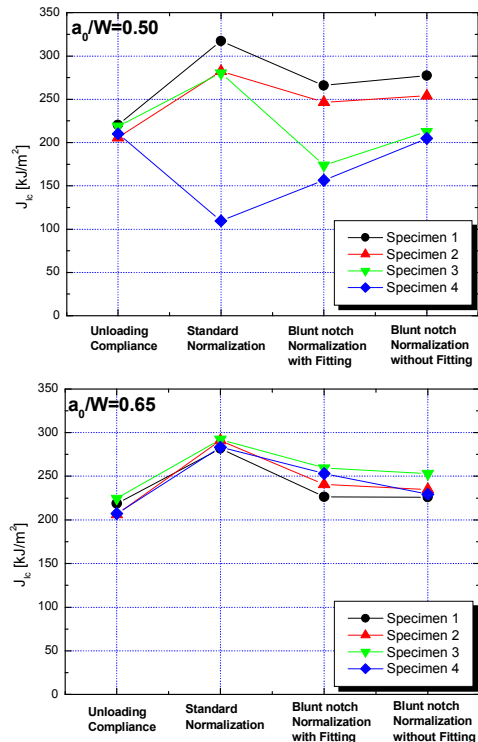

2.1 Static Loading Test

Proposed procedure for modified normalization method using blunt notch specimen was applied to low carbon steel material under static and dynamic loading condition. Tested material is SA106Gr.C nuclear piping steel, which is the same pipe block which was used in the normalization round robin under static loading condition[7]. One inch compact tension (CT) specimens were used.

Two number of the blunt notch specimens with 1 mm tip radius were tested for a_0/W=0.5 and 0.65. The measured data were applied to the raw data of the additional test in normalization round robin[7]. In order to quantify the differences, the J_{Ic} values were determined from the J-R curves determined by various methods. The following figure shows the J_{Ic} values for a_0/W=0.5. The J_{Ic} values determined by standard normalization method shows large deviation, but they are converged by modified normalization method, to the value by unloading compliance method. The next figure shows the J_{Ic} values for a_0/W=0.65. In here, standard normalization method overestimates the J_{Ic} values compared with unloading compliance method, but modified normalization method decrease these differences.
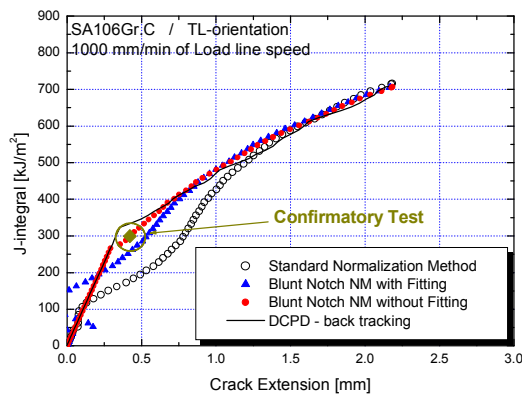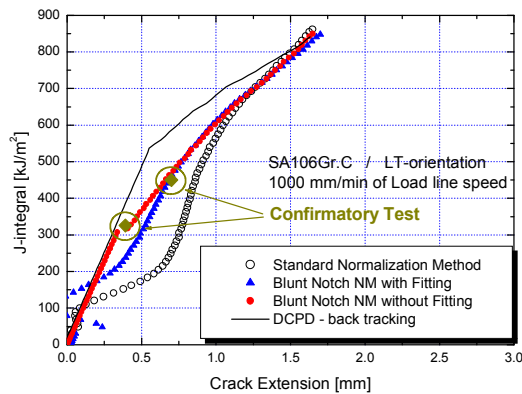

2.1 Dynamic Loading Test

The proposed procedure for modified normalization method was applied to the dynamic loading J-R test

with 1000 mm/min of load point speed. In order to compare with the other research's data, it was conducted for both LT and TL-orientation.

The following figure shows the J-R curves for LT and TL orientation, respectively, determined by standard normalization, modified normalization and DCPD method. The standard normalization method made large crack extension in the earlier region than the modified method. This shape of J-R curves by standard method is same as the unusual shape mentioned in the normalization round robin[7]. The blunt notch normalization method using curve fitting also shows similar shape with it because the normalization curves show the large yield point effect and these make the large deviation with the normalization curve fitting.

The confirmatory tests were conducted in order to confirm the validity of the modified normalization procedure using blunt notch test. In the confirmatory tests, the loadings were stopped in the J_{Ic} region and the specimens were broken open. The crack extensions were measured from the broken surface and J-R curves were determined by the modified normalization procedure using blunt notch test. This figure shows the confirmatory test results and these agreed well with the modified normalization procedure using blunt notch test proposed in this study.

the unreasonable one data and higher data were recovered to mean value region of unloading compliance method by proposed modified method. In dynamic loading condition, the large effect of yield point made the large error of standard normalization method. Compared with confirmatory test result, the modified normalization method using blunt notch specimen without fitting made very reliable J-R curves.

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3. Conclusion

The procedure for the modified normalization method using blunt notch specimen, was developed and applied to SA106Gr.C low carbon steel under static and dynamic loading conditions. In static loading condition,