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The Study on the Fracture Characteristic for the Nuclear Structural Material using Acoustic Emission

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1. Introduction

In order to evaluate the nuclear structural integrity, non-destructive test methods such as radiographic test, ultrasonic test and eddy current are generally used in the industrial field. However, these methods have restrictions that defect detection is possible after the crack growth. For this reason, Acoustic Emission Testing (AET) could be one of powerful inspection methods to verify the structural integrity of pressure vessels, high temperature reactors and pipes, and a number of other equipment because AET has an advantage that it is able to monitor the structure continuously.

Acoustic emission is defined in the ASTM standards as "the class of phenomena whereby transient elastic wave(s) so generated" [1]. These waves propagate through the material and cause surface displacements, which can be converted to electrical signals using a suitable transducer. AE signals can be basically characterized as burst and continuous type. Burst signals refer to acoustic emission events that are of short duration are well separated in time. The signal amplitudes are much larger than the background noise. On the other hand continuous signals refer to AE event, which have the form of a random oscillatory appearance devoid of distinguishing features. The AE events are closely spaced in time and form a single waveform. The signal amplitudes are only slightly higher than the background noise [2].

In this study, acoustic emission signal was collected from stainless steel 304 specimens and test was performed through tensile tests to verify the acoustic signal characteristic. And the fracture characteristic of specimen was studied using parameters relation analysis.

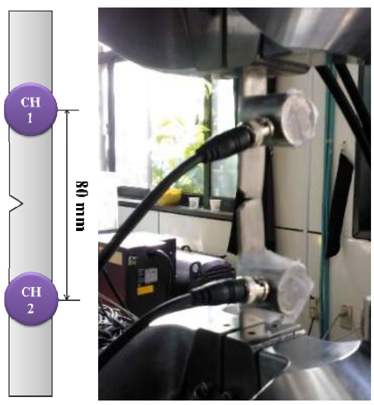

Fig. 1. Sensors fitting condition for the experiment

2. Methods and Results

2.1 Experimental Methods

The material and dimensions of the specimens are stainless steel 304 with 180 mm in length, 20 mm in width and 3 mm in thickness, which compose the primary structure of nuclear power plants and the acoustic sensors were attached as shown in Fig. 1 in order to collect proper fracture acoustic emission signal using 2-channels. For the test specimens, electrical discharge machining was used to produce the notch and all specimens were polished to aid detection and measurement of crack occurrence. The applied load was 5 mm/min and it was determined from the geometry of the test specimens and material properties, and remained fixed throughout the tests. The tests were continued until the specimens failed ultimately due to the crack growth or fracture. Acoustic emissions from all test specimens were monitored and recorded by an advanced DiSP-4 system and R15i sensors, with 150 kHz resonant frequency.

2.2 Experimantal Results

As shown in Fig. 2 and Fig. 3, the acoustic signals were mostly generated during the plastic deformation of the specimen. Contrary to carbon steel, the plasticity of the stainless steels starts with a very little acoustic activity and increases progressively with the crack propagation [3]. This characteristic is due to the nature of the plasticity which is a homogeneous deformation for stainless steel 304. The feasibility of applying the acoustic emission testing to detect the different stages of the ductile crack propagation in the stainless steel 304 specimen was verified from the experiments.

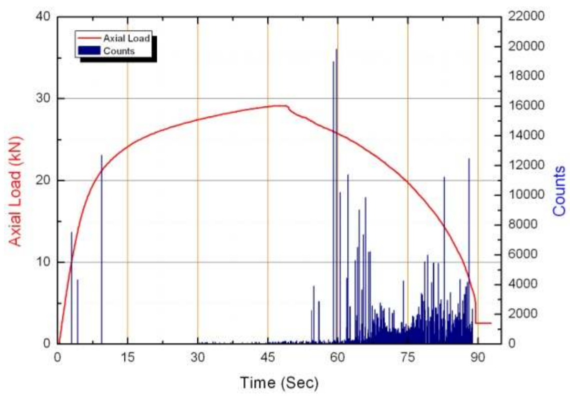

Fig. 2. Axial load and count histogram with the passage of time

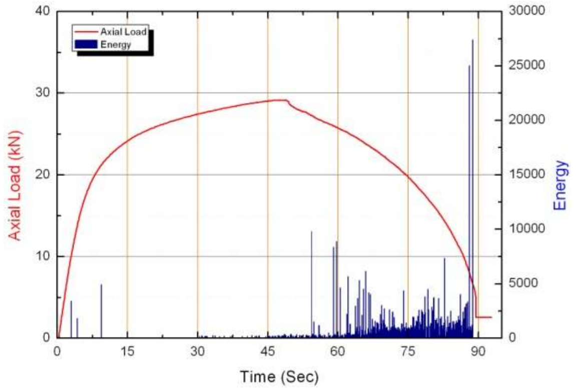

Fig. 3. Axial load and energy histogram with the passage of time

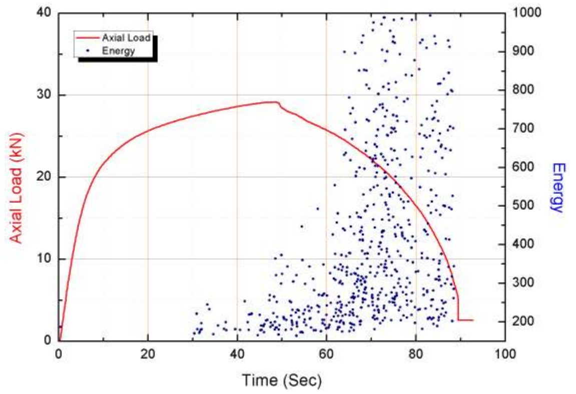

Fig. 4. Axial load and energy distribution with the passage of time

Fig. 4 shows the energy distribution that significantly increasing not only the hits but the strength after the crack occurrence.

3. Conclusions

The fracture characteristic of signal during tensile test in the stainless steel was examined by monitoring the acoustic emission testing. In spite of plastic deformation of most structural alloys generates AE signals when the specimen reaches a maximum near the yield point and diminishes, the result shows different AE signal distribution that the specimen generates large numbers of hits and the higher level of signal strength. This result is considered by means of the effect of notch shape on the specimen. Therefore, the acoustic emission signal analysis has to be distinguished whether there is the crack initiated or not.

4. Acknowledgment

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