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AE Characteristics of Stress Corrosion Crack in type 304 stainless steel pipe

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1. Introduction

Recently, the mechanical structures are getting bigger, faster and efficient. So the component materials demand the high strength, toughness, corrosion resistance, thermal resistance. Furthermore, the working environment for mechanical structure is more getting severe. To insure the health of structural material, the inspections of structure are more emphasized.

Acoustic emission(AE) is an easy method for detecting the formation of stress corrosion crack(SCC) on AISI 304 austenitic stainless steel pipe in laboratory experiments. Some studies have been conducted to investigate the characteristic of AE parameters during SCC propagation. But it has some difficulties to get at the root of distinct feature.

2. Experimental Procedure

2.1 Materials and equipment

Test was conducted at the high temperature and pressure condition, and the specimen was used a same scale of 3 inches pipe that used in the nuclear power plants. Inner surface of the pipe was welded using gas tungsten arc welding (GTAW) process to give specimen a residual stress. Experiment was performed in 1 M Na2SO4 and 2 M NaOH solutions.

2.2 Acoustic emission testing set-up

AE signals were acquired the sensor that model is S9125 (manufactured by PAC), which 400 kHz resonance frequency, mas using temperature 500℃ and used 1222 charge preamplifier. Threshold level of 40~45 dB was set as float type that can control the sensitivity of detection by keeping the voltage threshold of detection above the average background noise to minimize the noise effect. Once the signal had been detected from the sensors, this data was sent to 4 Channel DiSP (PAC) and then stored immediately on the specific storage. The AE data from the specimen was filtered from electrical and environmental noises.

3. Result and Discussion

3.1 Stress Corrosion Crack manufacturing

The stress corrosion crack was manufactured using the custom-made manufacturing system. Figure 2 shows the temperature and pressure variation during the test. As shown in Figure 1, the vapor pressure indicates the sudden dropping about 53 minutes (3200 sec) after the experimentation beginning. It could be explained that the pipe specimen was fractured about 3200 seconds by stress corrosion crack due to the accelerated corrosive condition.

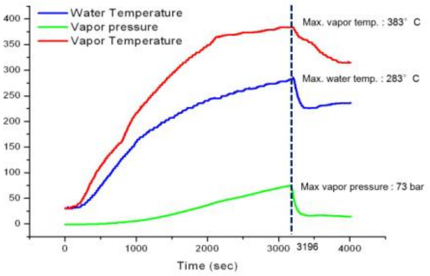


Fig. 1. Temperature and vapor pressure variation in the specimen

3.2 Metallographic observation

The signs of leaking were observed on the outer surface of pipe when the test was over. Figure 2 shows the cracks due to corrosive environments. Longitudinal direction cracks were found at outer surface which is regarded as a surface level of solutions. However, the crack expected to generate at welding bead was not found. A deep crack was observed with lots of small branches. The cracks advance through the crystal grains.

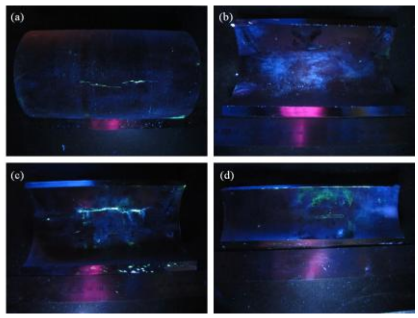
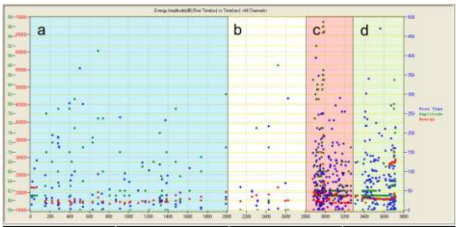


Fig. 2. The fluorescent penetrant testing result (a) outer surface (b) inner surface of solution surface level (c) inner surface of solution surface level (d) welding bead

3.3 Acoustic Emission

The cumulative counts increased smoothly until about 2000 seconds and the degree of increase was reduced gradually. About 2800 seconds, the cumulative counts were increased rapidly until the test was over. Fig. 4 shows that AE signals were intensively generated around pressure drop position. And the value of Energy and Amplitude was relatively high.



Region	Energy	Amplitude	Risetime
a, b	Low	-	-
c	High	High	High
d	Low	Low	High

Fig. 4. Energy, amplitude and risetime distribution with time during SCC of AISI 304 stainless steel in 1M Na2S and 4M NaOH

Fig. 8 shows four specific waveforms detected during SCC process. Waveform (a) detected at heating time has a characteristic that looks like continuous emission. Waveform (b) has a characteristic that peak amplitude takes precedence and the value of amplitude falls off. Near to maximum temperature and pressure, waveform (c) was sprinkled with former AE signal generating pattern. The characteristics of waveform (c) are time delay which exists until peak amplitude is detected. Waveform (d) with irregular waveform pattern was occurred when pressure drop was happened.

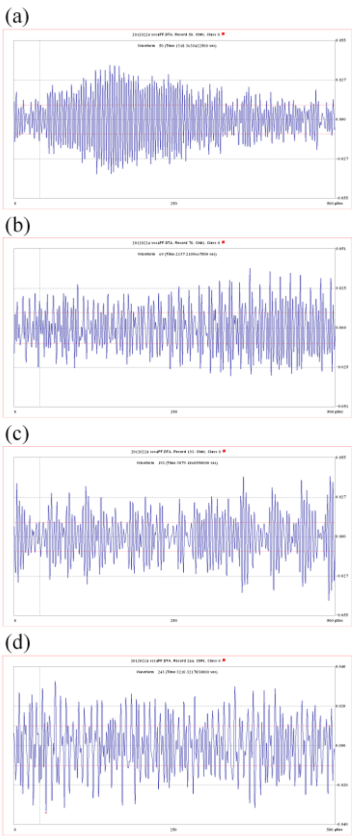


Fig. 8. Specific waveforms during SCC propagation

4. Conclusion

On the basis of the presented experiments, the following conclusion have been made :

(1) Stress corrosion crack was able to be artificially manufactured on the 304 austenitic stainless steel tube.

(2) The events of the AE signals increase under the pressured condition with high temperature. Increasing tendency of AE counts is similar to former studies using flat bar or CT specimen. The number of AE counts rapidly increased near to the pressure drop.

(3) During SCC manufacturing process, specific AE waveforms were generated in the order. It can be used to distinguish SCC damage stages and help supervisor to repair the damage before the deep crack generates.

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