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Characteristics of acoustic emission from corrosion in anticorrosive-coated steel

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Abstract. Corrosion in infrastructures made of steel is a serious problem. Corrosion protection paint is generally utilized on steel structures. However, corrosion progresses under the coating films because of the deterioration of the coating films. Generally, visual and hammering inspection is widely used for inspecting infrastructures. A new nondestructive method to evaluate the corrosion of coated steels and the degradation of coating films is needed because present inspection methods are costly, time-consuming, and inaccurate. In this study, an acoustic emission (AE) method was applied to evaluate the corrosion condition of coated steel. An AE monitoring test during accelerated corrosion was carried out. A 3% NaCl solution was sprayed on a coated steel specimen and a bare steel specimen every 24 h for 90 days to accelerate corrosion. The AE events generated from the specimens were monitored continuously, and the corrosion activity was assessed by the change of the cumulative AE events. The assessment showed different behaviours of cumulative AE events between the coated steel specimen and the bare steel specimen. Moreover, a classification using frequency analysis was carried out for the AE signals generated from the coated steel specimen. As a result of the analysis, the conditions of the coating films and the under-film corrosion were estimated.

1. Introduction

Corrosion is a serious problem for steel structures, and coating is the most popular method of corrosion protection. However, corrosion preventing performance of the coating films deteriorate because of its aging, and corrosion spread under the coating films [1, 2]. In order to prevent the accident and reduce LCC (Life Cycle Cost), it is important to perform maintenance adequately. Generally, a visual and hammering inspection is widely used for inspecting infrastructures [3]. However, such methods have problems of cost, accuracy and objectivity. Additionally, inspectors have to evaluate by destructive paint removing test due to check the under film corrosion. Thus a new inexpensive and simple nondestructive inspection technique is required.

The acoustic emission (AE) method is a powerful tool for monitoring corrosion. AE signals are excited by fractures in rust during its growth [4]. Even though researchers have applied AE method to corrosion, many parts of the relationships between corrosion and AE characteristics remain unexplained [4-6]. Additionally, much less work has been done on AE characteristics of coating film deterioration and under film corrosion in anticorrosive-coated steel. The aim of this study was to develop an AE monitoring technique for the corrosion condition of anticorrosive-coated steel. Continuous AE monitoring for coated and bare steel specimens during accelerated corrosion was carried out, and the relationship between the AE activity and the amount of corrosion and coating damage was estimated.

2. Experiment

Continuous AE monitoring was carried out as shown in Figure 1. The specimens were made of SS400 with measurements of 30 mm^{W} × 300 mm^{L} × 2.2 mm^{T}. One was coated with anti-corrosive coating (zinc-rich coating), the other was bared. The specimens were placed in a humid environment and a 3% NaCl solution was sprayed on them every 24 h to accelerate corrosion. The AE signals from corrosion were detected by PZT sensors (PAC, R15α) which have resonant frequency at 150 kHz and recorded with a digitizer after passing through a pre-amplifier (40 dB) and a high-pass filter (10 kHz).

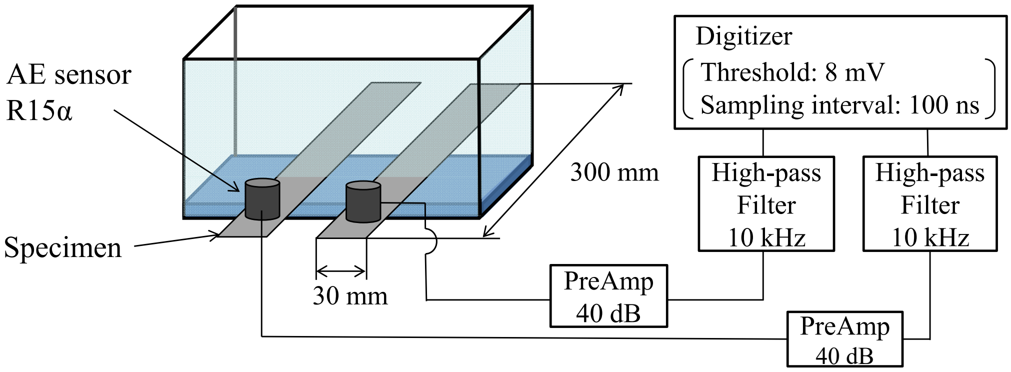


Figure 1. Experimental setup for monitoring AE signals during aged test

Figure 2 shows changes in the surface of the specimens. Both specimens made significant changes in appearance. In the bare steel specimen, a rust lump grew into a layered rust and it made delamination in the day 75. On the other hand, in the coated steel specimen, a rust grew up under the coating film and oozed out on the coating films in the day 59. The results of the cumulative AE events are presented in Figure 3. As shown in the figure, there were high AE activity time frames in the both specimens (bare steel: Day 70–90, coated steel: Day 35–60) during which significant changes occurred in their appearance. Therefore, a correlation exists between the cumulative AE events and the corrosion condition.

Figure 2. Surface photographs of specimen during aged test

Next, in order to estimate a condition of under film corrosion in more detail, we classified the AE signals generated from the coated steel into a coating AE and a corrosion AE using frequency analysis. Our previous study had indicated that it can detect AE signals generated from fracture of coating films and it have low frequency components compared with those of corrosion [7]. Therefore, we defined the AE signals with a peak frequency under 100 kHz as the coating AE and those around 150 kHz peak frequency as the corrosion AE. Typical AE waveforms and frequency spectra of coating AE and corrosion AE ware shown in Figure 4. Figure 5 shows the results of the classification. This figure indicates the AE generation mechanism of the under-film corrosion. The corrosion AE increased in time frame 1, while both the coating AE and the corrosion AE increased at the same time in time frame 2. Therefore, these results show the possibility of monitoring under-film corrosion using the AE method.

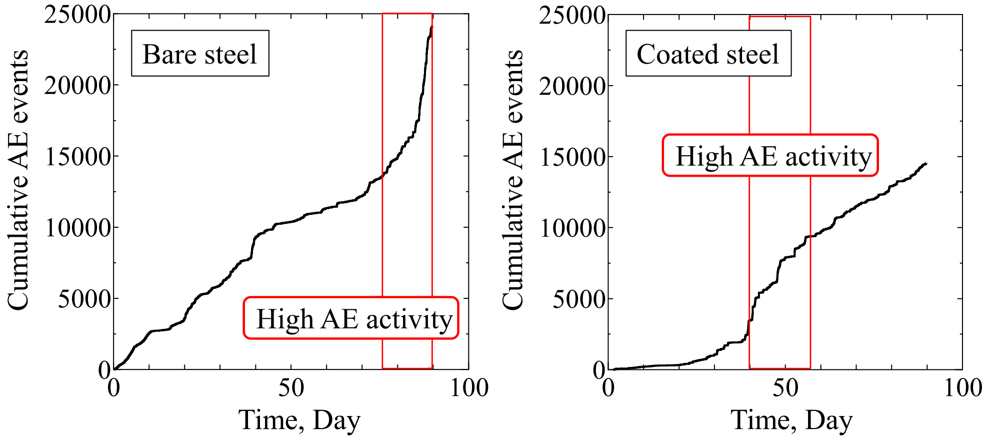
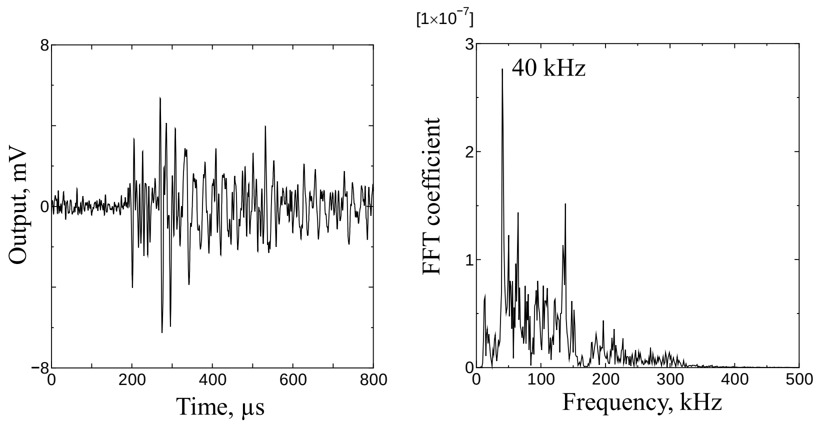
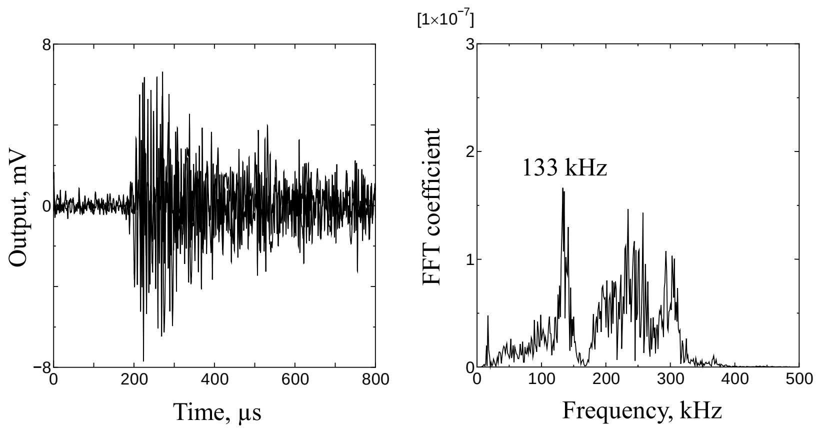


Figure 3. Cumulative AE events of bare-steel specimen (left) and coated-steel specimen (right) during the aged test.



(˘) Coating AE



(˘) Corrosion AE

Figure 4. AE waveform of (i) Coating AE and (ii) Corrosion AE (left) and their frequency spectra (right).

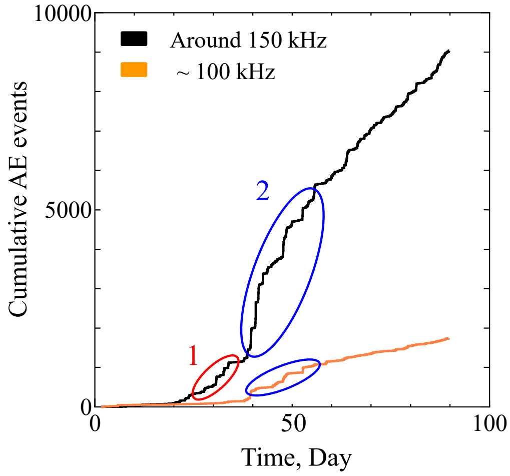


Figure 5. Cumulative AE events classified using frequency analysis.

3. Conclusion

In this study, a continuous AE monitoring test for coated- and bare-steel specimens during accelerated corrosion was carried out for 90 days and was found to estimate the corrosion activity by the change in cumulative AE events. Moreover, a frequency analysis applied to the AE signals showed that it was possible to assess the condition of under-film corrosion.

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