

Study on Spectrum of Acoustic Emission Signals of Bridge Crane

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Abstract

The characteristics of acoustic emission signals were studied by performing AE test for more than 20 bridge cranes and destructive test of one box beam. The results indicate that AE sources of bridge cranes are mainly from cracking, plastic deformation, structural friction, the noise of vehicle and trolley, and et al. It was found that the peak frequencies of AE signals near 130 kHz and 330 kHz respectively for crack growth, 150 kHz for plastic deformation, 70 kHz for structure friction and 90 kHz for vehicles moving. AE test is a good and quick nondestructive testing and safety evaluation method for bridge cranes.

Keywords □ Acoustic emission, Crane, Spectrum, Frequency, Wavelet analysis.

1 Introduction

Crane is one type of special equipment because it possesses fatalness to happen accident during operation in China. Cranes are extensively used in hoisting, transporting, loading, installation and so on. According to the statistic at the end of 2008, there are 1183 thousands of cranes in China^[1]. The safety and reliability of the crane are very important. The in-service inspection should be performed once a year. The nondestructive testing methods in common used in service cranes are Viewing Test (VT) and Magnetic Test (MT)^[2]. But VT is difficult to find cracks and MT needs to burnish all welds. In addition, it is very difficult to perform VT and MT for whole steel structure of the crane without scaffold.

Due to acoustic emission (AE) is a dynamic nondestructive testing method for steel structure, it should be a good testing method for cranes during loading. However, only a few research papers were found for the application of AE testing of cranes^[3-6]. No published acoustic emission testing standard of cranes was found in the world. In order to draft acoustic emission testing standard for bridge crane, the characteristics of acoustic emission sources were studied by performing AE test for more than 20 bridge cranes and destructive test of one box beam. A fully digital multi-channel AE system series AMSY-5 was used in the test. The VS900-RIC wide band sensor and the AEP4 preamplifiers were used to acquire the waveforms of AE signals.

2 AE signals of crossbeam during destructive testing

2.1 Testing equipment and procedure

In order to investigate the characteristics of AE signals during loading, a crossbeam of crane which size is $5800 \times 300 \times 200$ mm was fabricated as the specimen. The material of the crossbeam is Q235B carbon steel which thickness of plate is 5 mm. One surface welding crack which length is 130 mm was prefabricated on the down cover plate of the box beam. The load was put on by 3-point bend. Figure 1 is the sketch map of the crossbeam and sensor layout for AE test. Figure 2 is the picture of this AE testing.

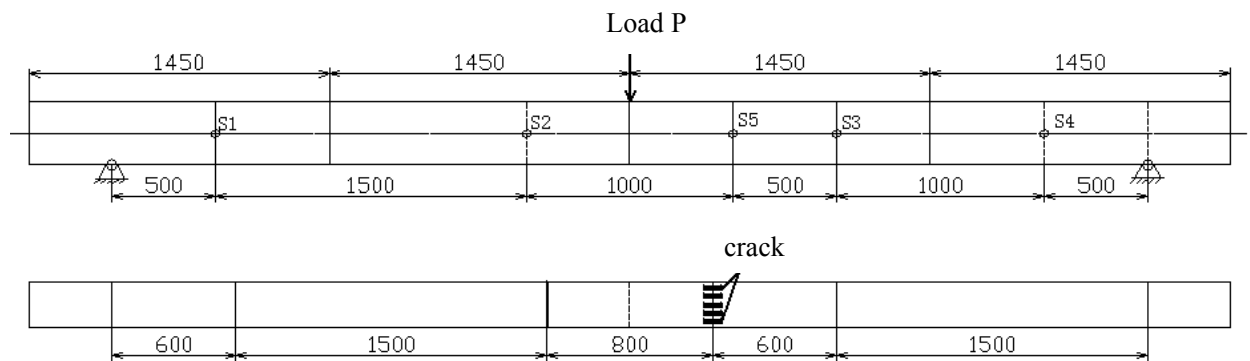


Fig. 1 Sketch map of crossbeam and sensor layout for AE test



Fig. 2 Picture of AE testing for crossbeam

2.2 Characteristics of AE signals of crack growth

The load was put from 0 to 80KN step by step. The crack did not grow clearly from 0 to 30KN loading. It grew 20mm from 30KN to 60KN loading and 30mm across the plate from 60KN to 80KN. Figure 3 shows the pictures of the surface cracks on the crossbeam before and after loading.



(a) Prefabricated

(b) After 80KN loading

Fig. 3 Pictures of the surface cracks on the crossbeam

Figure 4 shows the AE location from 30KN to 60KN load. The linear location monitoring was performed by sensor 2 and sensor 3. The press head locates on 45cm of the X-axis. The crack locates on 95cm of the X-axis. In order to reduce other disturbing location signals, the plots are spatially filtered to only accept activity located between 80 and 110 cm.

The time domain waveforms and its frequency spectrum after applying Fast Fourier Transformation (FFT) of the AE signals produced by crack growth are shown in Figure 6. From the figure 5 we know that, the AE signals of crack growth are bursting emission, the range of its frequency spectrum distributes widely from 100 kHz to 500 kHz, and have the peak value in 130 kHz, 330 kHz, and 450 kHz respectively. The wavelet analysis was performed for this AE signal which is shown in Figure 5. The three axes in figure 5 are wavelet transform (WT) coefficients, frequency (kHz) and time (μ s) respectively. There are two energy peaks near 130 kHz and 330 kHz.

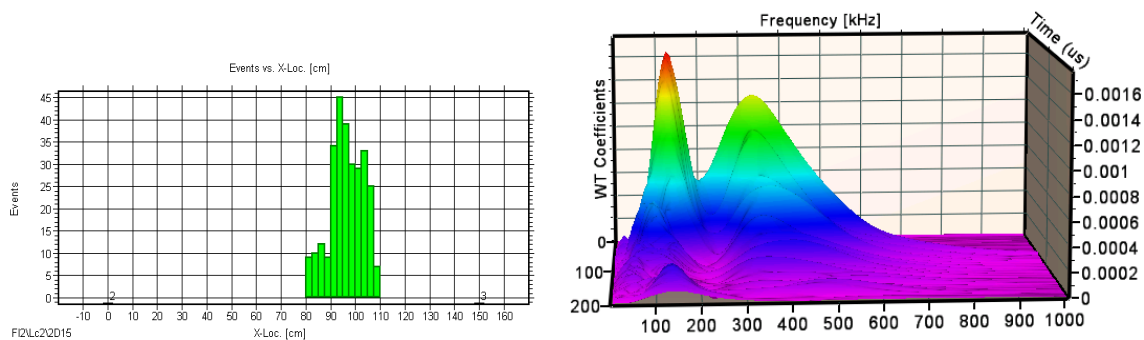


Fig. 4 AE source location on 30□60KN

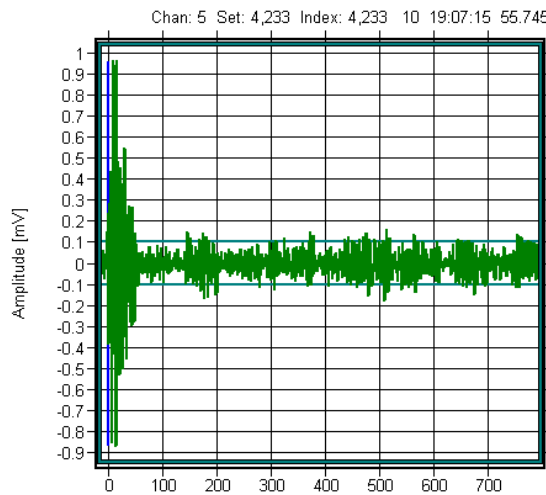


Fig. 5 Wavelet analysis of AE signal

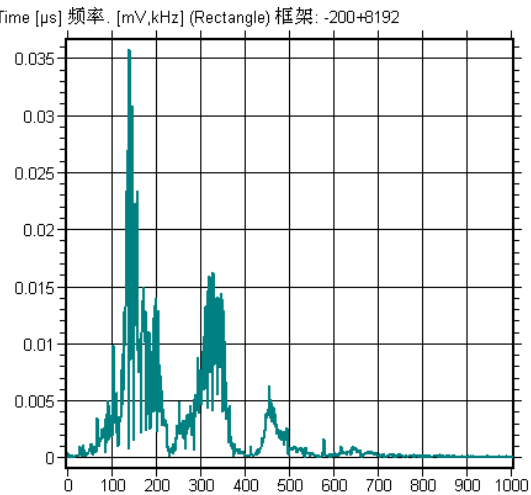


Figure 6 Waveforms and frequency spectrum of AE signal of crack growth

2.3 Characteristics of AE signals of plastic deformation

The AE signals of the plastic deformation were obtained by use of the 3-point bending test for the crossbeam. Figure 7 shows the pictures of plastic deformation after first and second 80KN loading. The plastic deformation was appeared in the first loading. The crossbeam was completely destroyed after second loading at 80KN.



Fig. 7 Picture of the plastic deformation on the crossbeam

There are a lot of AE signals caused by the plastic deformation of the crossbeam, some could be located. Figure 8 shows the hits vs. time for sensor 2 for the whole loading process of the crossbeam. Figure 10 shows the time domain waveforms and its frequency spectrum after applying FFT of the AE signal of plastic deformation. The range of its frequency spectrum distributes from 100 kHz to 200 kHz mainly, with the peak value in 150 kHz. The wavelet analysis was performed for this AE signal which is shown in Figure

9. There is one energy peak near 150 kHz.

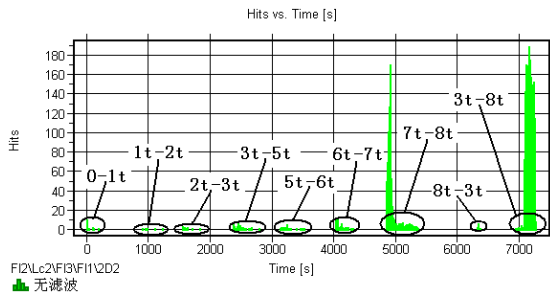


Fig. 8 Hits vs. time for sensor 2

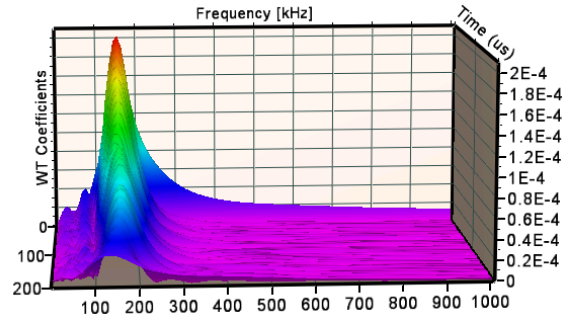


Fig. 9 Wavelet analysis of AE signal

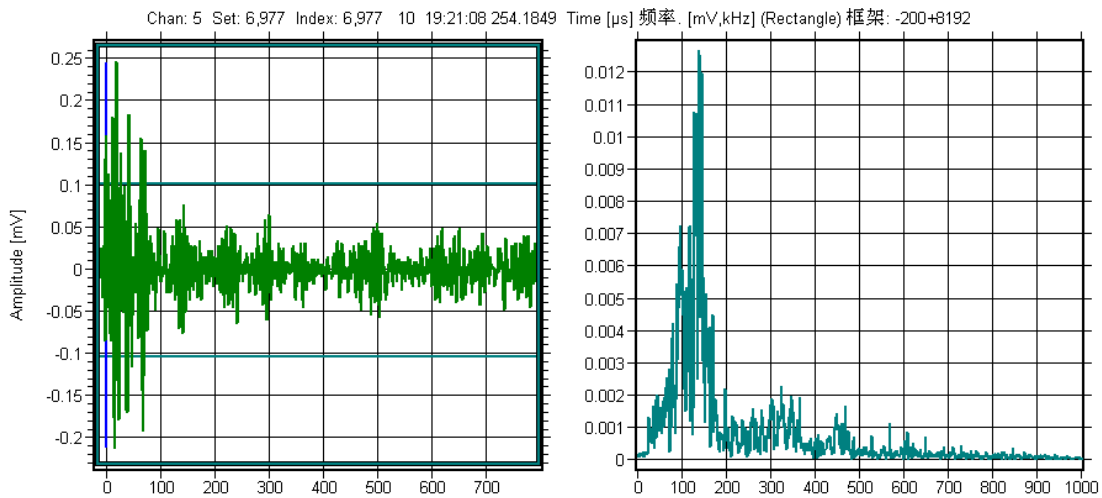


Fig. 10 Waveforms and frequency spectrum of AE signal of plastic deformation

3 AE signals of bridge cranes in the field

3.1 Structure friction

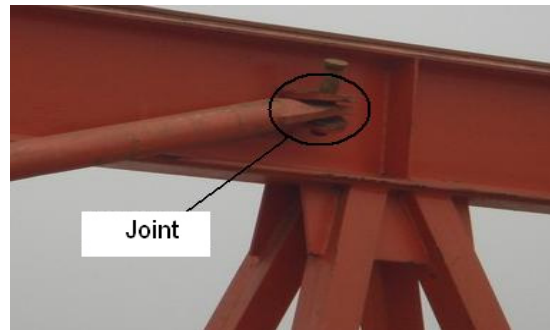
Sometimes, the structures of the bridge crane are connected by rivets or bolts. The structure friction of the joints can result in AE signals. Figure 11 shows the picture of a ZTQJ40/140 bridge crane with girder erection structure. The girder joints, joint of the temporary rod crossing for the girders, and the interface between the temporary rod and the truss are shown. A lot of AE source location signals emerged in the places of the nodes, joint and the interfaces during loading. Figure 12 shows the AE source location characteristics of the structure friction.

The Figure 14 shows the domain waveforms and its frequency spectrum after applying FFT of AE signals produced by structure friction. Its frequency range distributes from 50 kHz to 180 kHz mainly, with the peak value in 70 kHz. The wavelet analysis was performed for this AE signal which is shown in Figure 13. There is one energy peak near

70 kHz.



(a) trolley



(b) the joint

Figure 11 AE Testing picture of one ZTQJ40/140 bridge crane

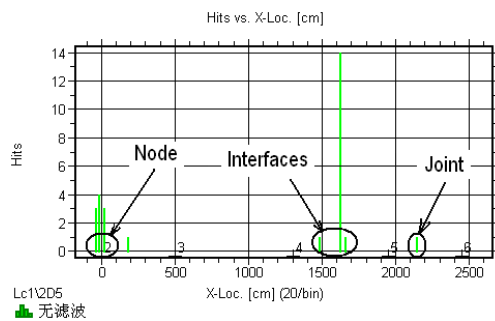


Fig. 12 AE source location

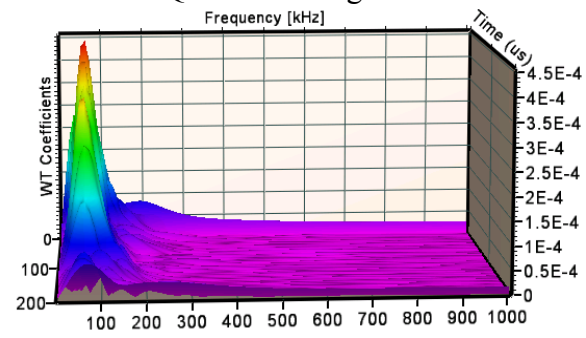


Fig. 13 Wavelet analysis of AE signal

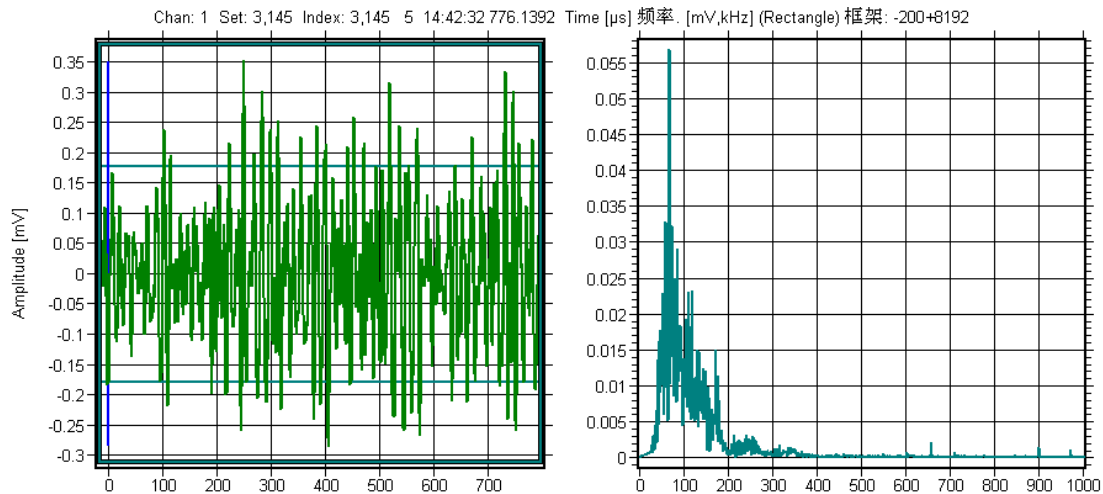


Fig. 14 Waveforms and frequency spectrum of AE signal of structure friction

3.2 Noise of vehicles and trolleys

The moving of vehicles and trolleys often brings on lots of AE signals when the bridge crane is operated. Even if in the station of holding load, the friction between the trolley and railway can also bring on noise. Figure 15 shows the AE source location of noise caused by the vehicle while moving on a QD20/10t-22.5 bridge crane. The wheels

were located near the sensor No.2 and sensor No.6 in the two sides, so the AE Events caused by the vehicle can be located while it was moving. The trolley was located near the sensor No.4, and the AE Events caused by the trolley also had been located nearby the sensor No.4.

The Figure 17 shows domain waveforms and its frequency spectrum after applying FFT of AE signals produced by vehicles moving. From the figure we can find that the waveforms are continuous emission. Its frequency range distributes from 50 kHz to 100 kHz mainly, with the peak value in 90 kHz. The wavelet analysis was performed for this AE signal which is shown in Figure 16. There is one energy peak near 90 kHz.

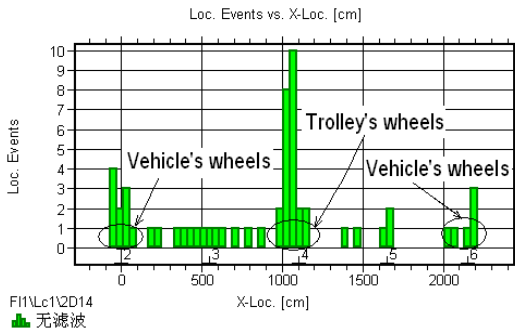


Fig. 15 AE source location

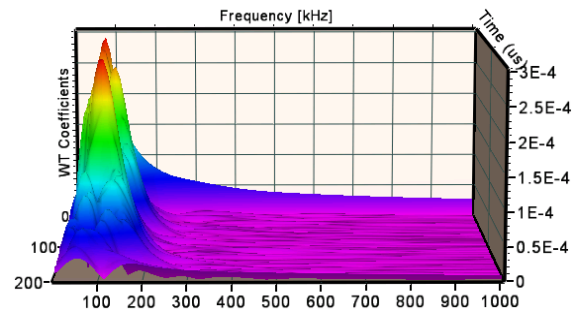


Fig. 16 Wavelet analysis of AE signal

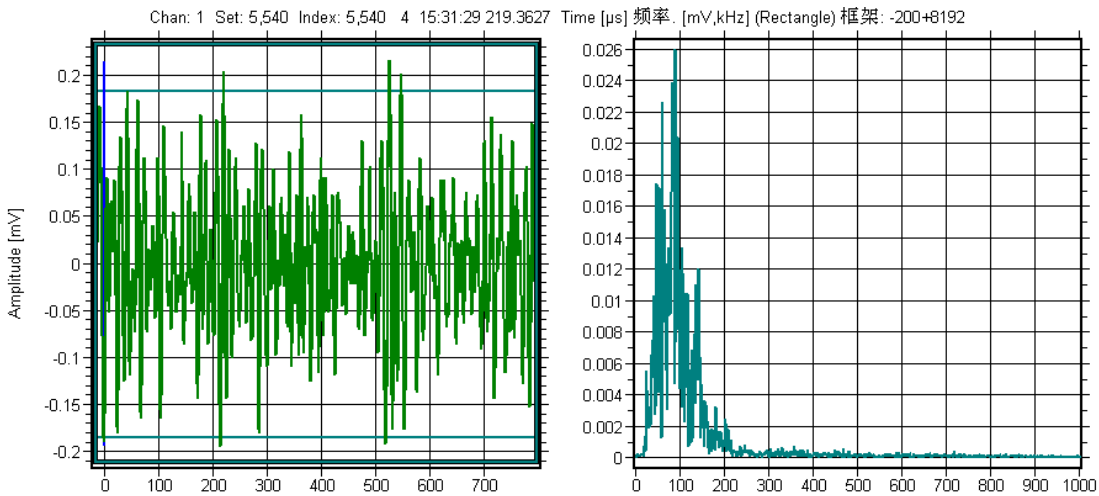


Fig. 17 Waveforms and frequency spectrum of AE signal of vehicles noise

4 Conclusion

(1) The AE sources of bridge cranes are mainly from cracking, plastic deformation, structural friction, the noise of vehicle. These AE sources can be located.

(2) There are two frequency spectrum peaks near 130 kHz and 330 kHz respectively for crack growth, one peak near 150 kHz for plastic deformation, one peak near 70 kHz for structure friction, one peak near 90 kHz for vehicles moving.

(3) AE test is a good and quick nondestructive testing and safety evaluation method

for bridge cranes.

Acknowledgement

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