Experimental Study on Defects Testing of Crane based on AE

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Abstract: The online location and feature identification of the conventional defects such as cracks is the key to crane safety evaluation and accident prevention. SDAES acoustic emission (AE) detector and GPS-100 high frequency fatigue tensile testing machine are used to collect and analyze the AE signals of specimens of Q235 material, cracks and welding defects under different loading conditions, and then fault location estimation as well as signal and spectral characteristics analysis of conventional defects are achieved by applying signal processing techniques. Finally, the main characteristic parameters distribution ranges are analyzed from the typical AE experimental signal of Q235 material and conventional defects samples. Research in this paper provides basic data and technical reference for the application of AE to crane hazard detection.

1. Introduction

With the widespread use of crane machines, there is a huge amount of property damages and personal injuries in both foreign and domestic markets. The online location and fault feature identification of hazard sources including crack and welding defects is the key to crane safety evaluation and accident prevention. Due to the complexity of obtaining AE signals in field condition and the lack of typical samples of AE source parameters, the research of crane NDT based on AE is still in the exploratory stage. Kaiser discovered that copper, steel, and metal alloy and metal alloy have AE phenomena in the event of deformation [1]. Javadi Y and Sadeghi S studied the elastic wave propagation characteristics of crane plates, and with the help it's possible to locate linear source [2] .Some researchers describe the damage evolution and failure mechanism of specimens at different failure stages by using the parameters of AE event number, amplitude, energy and duration [3, 4].AE refers to the phenomenon of transient elastic waves generated by the local rapid release of energy. The frequency and amplitude of the AE emitted in different conditions and processes is quite different.AE elastic waves can reflect some physical properties and damage of materials or components. Therefore, the method of detecting AE signals can be used to judge the state of machine. In order to locate the defect position on the material surface, several sensors should be placed on the fixed point according to certain geometric relations. The position of the AE source is determined by the AE signal detected by sensors, this method is called source localization.

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2. Experiment

To solve the problem of the conventional defect detection of the crane, we design an AE experiment containing the Q235 specimen of the non-crack, crack and the welding defect. We use the signal analysis technique to analyze the defects, parameters and the wave characteristics. The results indicate that the AE technology is effective in detecting and evaluating crane operating status.

2.1 Specimen preparation

The tensile specimens are divided into three types, which are non-defect, crack defects and welding defects specimen. To explore different acoustic signatures in the same size specifications. At the center of the specimen, we have made a crack which is 5mm wide, 1mm deep and through the entire specimen. The welding defect specimen (Fig.1) are prefabricated with type I slope, which is 2 mm wide and through the entire specimen.

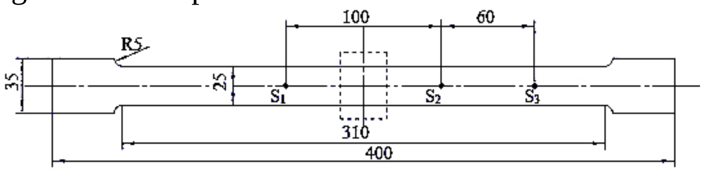


Fig. 1 Q235A dimensions of defect free tensile specimens

2.2 Experimental equipment

We use GPS-100 high frequency fatigue tensile testing machine to implement the test load anddetect AE signals by SDAES AE detector made by Soundwell.corp.

2.3 Experimental system

The whole test system consists of hardware and software systems(Fig.2).

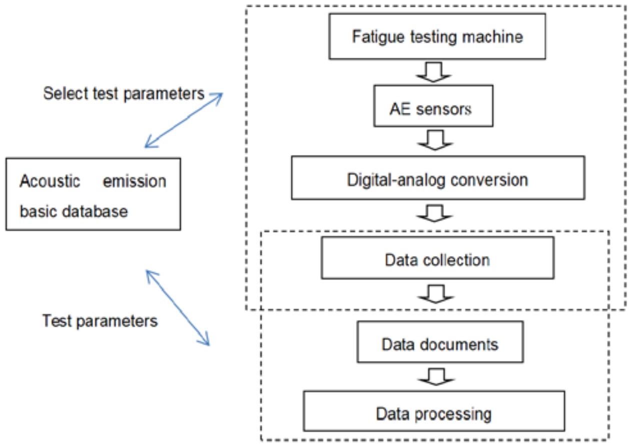


Fig.2 Architecture and principles of the test system

2.4 Layout of the sensor

For all the three types of specimens, three sensors S1,S2,S3 were used to form one-dimensional linear localization (Fig. 1). AE detection was carried out on the specimens to record AE signals.

3. Results

3.1 Analysis of AE parameters in tensile process of cracked Q235 specimen

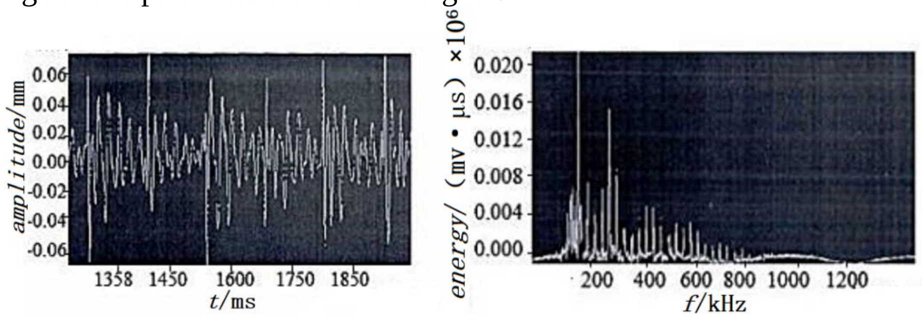
The location analysis in Table 1 is a statistical table of AE events during four load processes

Table 1 AE positioning event statics of specimen loading process

steps	loading(kN)	Main location position(mm)	Number of events	note
1st	6-10	40	8	Flawed position
2st	10-15	40	4	Flawed position
3st	15-20	40	5	Flawed position
4st	20-27.86	40,72,86,118	7	Dispersed distribution

As shown in table 1, of all 24 finally calculated localization points, 10 registration points are located at the crack defect point, which is the main location concentration area. Other location have a wide range of distribution. It can be seen from table 1 that the AE linear localization method can be used to accurately locate the crack defects of specimens.

The counts, Energy, history Amplitude and Hits diagram shows the characteristic parameters of AE signal of crack growth during the process of loading. The counts, energy and hits distribution are distributed uniformly, while the distribution of amplitudes occurs in two central areas, near 40 db and 54 db respectively. Analysis shows that the peak value near 40dB is caused by the residual stress of the specimen, the friction between the specimen surface and the fixture, and the signal generated by the weak dislocation motion in the material; The signal of 54dB and above is caused by the strong AE source generated by crack initiation and propagation. Table 2 is the main distribution range of the parameters of the AE signal.



(a)oscillogram (b)spectrogram

Fig.3 The waveform and spectrogram of the AE signal on with surface crack propagation

Table 2 AE signal parameters range of surface crack propagation stage

	Amplitude (dB)	Energy (mv • μs)	hits	Lasting time (μs)	Raising time (μs)	RMS (dB)
distribution	40-75	0-2514	1-64351	0-1.1×107	0-2.1×106	1773-4503
Main range	48-60	300-14524	244-37510	6800-1.9×10^5	4500-1.5×10^5	2500-3300

Fig.3 shows the waveform and spectrum of AE signals of the crack growth stage. The frequency range of AE signals is distributed within the range of 90-650kHz, and the main frequency range is 90-130kHz and 108-260kHz,The peak values of 430kHz and 630kHz are obvious, and the main energy is concentrated in the first frequency band.

3.2 Analysis of AE signal parameters of welding-defected Q235 specimen

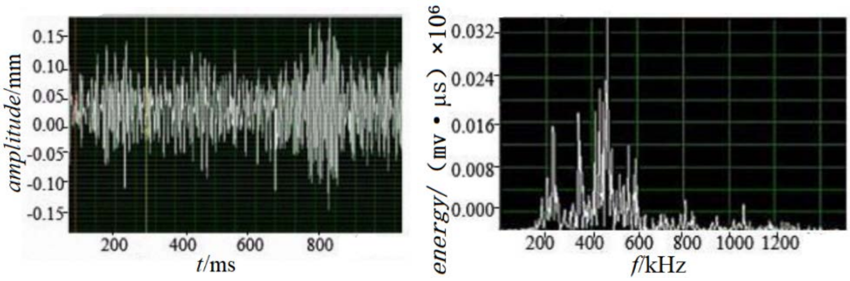
The welding defect of prefabricated specimen is located at 120mm.And table 3 is the statistical table of AE localization events of the specimen.

Table 3 AE positioning event statics of specimen loading process

Load process	loading(kN)	Main location area(mm)	Number of events	note
1st	6-10	122-125	3	Focus on the defect
2st	10-15	122-125	5	Focus on the defect
3st	15-18.5	——	——	——

It can be seen from Table 3 that the main AE location area overlapped during the first loading and the second loading, and the maximum deviation from the actual defect location was 5mm, less than 5% of the sensor spacing, approaching the requirements of positioning accuracy.

The characteristic parameter detected by AE in defect expansion processing during the loading process shows that in the low stress loading process, the signal is mainly continuous and contains a small amount of signals generated by residual stress and friction between specimen and fixture;When the load rises to the second stage, the energy rate increases to the peak value, and cracks are generated inside the welding defects and then expands.It can be seen from the course map that the AE of the welding defect specimen is high in amplitude, and the concentration of the AE signals is near 58dB, and the number of impacts is almost 1, and the counts is mostly lower than 34000.



(a)Oscillogram (b) Spectrogram

Fig.4 The waveform and spectrogram of the AE signal on welding defects

Fig.4 shows the waveform and spectrum of AE signal generated by defect expansion during the loading process. The signal band range is 90-540kHz, and the main energy distribution is in the range of 100-300kHz, and the peak value appears near 230kHz.Table 4 is a summary of the distribution range of main parameters of AE signal of welding defects.

Table 4 AE signal parameters range of welding defects specimen

	Amplitude (dB)	Energy (mv·μv)	Hits	Lasting time (μs)	Raising time(μs)	RMS (dB)
Range	56-85	521-3.8×10^6	225-65281	5500-1.3×10^8	5000-1.4×10^8	3143-4877
Main range	56-65	750-2.8×10^5	750-33486	1.2×10^4-1.0×10^8	7200-5.1×10^5	3200-3600

4. Conclusions

(1) The analysis of characteristics of AE signal and the location diagram shows that：AE technology can realize fault localization of two conventional defects,which are crack and welding defects, and localization accuracy is within 5%.

(2)In the tensile process of cracked Q235 specimen, the frequency band of typical Hit signal distribution is within 90~130kHz and 180~260kHz, and the maximum peak appears around 100kHz.In the tensile process of welding-defected Q235 specimen, the Hit signal frequency band mainly distributed in the range of 100-300khz and the peak value appeared near 230kHz. As a result, the feature identification of the two conventional defects can be realized.

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