Research on Simulation and Experiment of the Electromagnetically Induced Acoustic Emission Based on High-Current Loading

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Abstract —Electromagnetically induced acoustic emission (EMAE) technique is a new nondestructive testing (NDT). It did nondestructive detection with the effect of dynamic electromagnetic loading to generate a stress field stimulating stress waves from the defects. The principle and implementation procedure of the EMAE is deeply analyzed in this paper, and the finite element model (FEM) is set up. The experiment of defect detection is achieved. It analyses the influence of detection conditions, loading conditions and specimen type on the EMAE signal in detail. At last, it verifies that it could excite the phenomenon of EMAE in the metal plate with the crack by means of time-frequency analysis to the experimental signals by using FFT.

I. INTRODUCTION

Electromagnetically induced acoustic emission technique (EMAE) is a recently developed nondestructive testing technique. It can locate small flaws or cracks in thin-walled structures nondestructively to allow inspection of specific areas without loading the whole structure and it avoids additional damage using Electromagnetic loading instead of mechanical loading [1], so it assembles advantages of electromagnetic Non-Destructive Testing and acoustic emission (AE) Non-Destructive Testing.

II. THEORY AND SIMULATION

It is known that a high current going into the metal conductor will bring about concentration effect in the tips of the conductors' defect, such as stoma, flaw, and inclusion [2], [3]. Fig. 1 shows the current density in conducting materials containing flaws is about one order higher than other. Under the external magnetic field, the Lorentz force around the crack tip will be much bigger than other parts. If the Lorentz force is large enough to excite AE signal, it can be used to locate the defect in the conductor [4]. Because defect is the AE source, tiny breaks hidden in the metal component can also be detected and located [3]. Thus the technology has great potential in high reliable industry applications, such as space aviation, storage tank and gas pipeline construction rig.

III. EXPERIMENTAL PROCEDURE

Crack around the edge of bolt hole in the large metal structure is commonly damage in engineering. Circular via hole with a diameter of 10mm is used to simulate the bolt hole. Prefabricated crackle, 26mm in length, is at the edge of via hole. The two aluminum specimen used in this experiment has a thickness of 1.20 mm and planar dimensions of 115 mm×500 mm. Sample 1# contains hole and crack and Sample 2# doesn't.

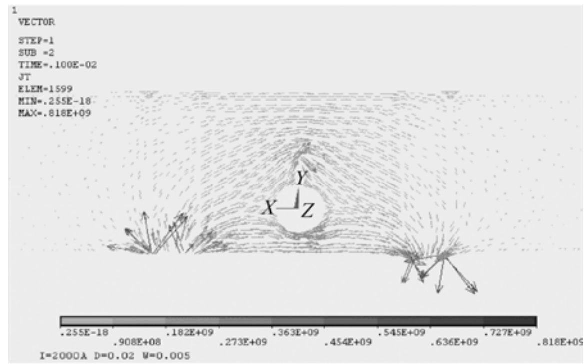


Fig. 1. Vector illustrations of current density

Sensor arrangement and current loading position is shown in Fig. 2. The pulse-current loading unit is designed and applied in the detection experiment of Aluminum crack [5]. Through loading current in the samples, we can acquire the waveform of EMAE signal.

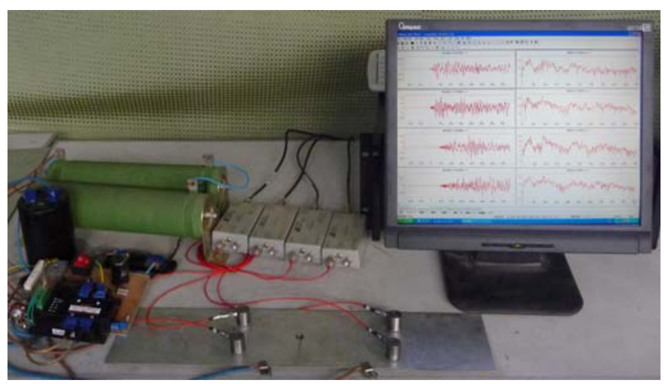


Fig. 2. The equipment for EMAE experiment

IV. RESULTS AND DISCUSSION

A. *Influence of propagation attenuation on the signals*

Attenuation test of the aluminum specimen was carried out. As in Fig. 3, propagating attenuation with the distance of 300mm was about 10dB. Because the size of the specimen is small and the propagating distance is short, the effect of propagation attenuation on the EMAE signals is so little.

B. *Influence of current amplitude on the signals*

The current amplitude directly decided the current density at the crack tip. In the experiment, the loading current started with 320A, increasing up to 2100A. When the loading current is less than 800A, signal amplitude and energy is very small and the acoustic emission is so low that flaw inspection can't be achieved.

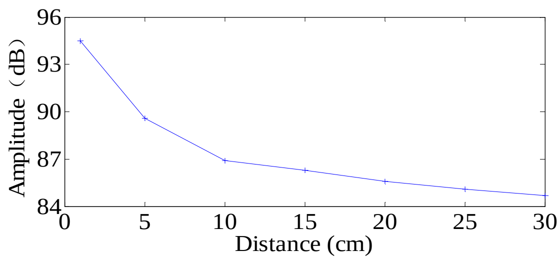


Fig.3. Attenuation of the AE amplitude of the propagation distance

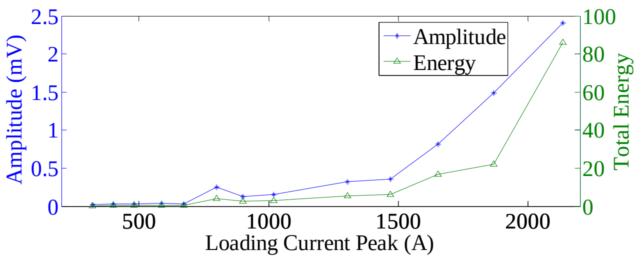


Fig.4. EMAE signal with different loading current

C. *Influence of current duration on the signals*

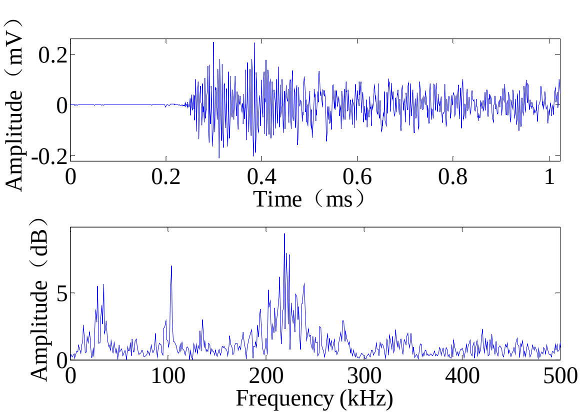
Increase in the current duration should not lead to raise the EMAE signal peak, but the total energy of signal will rise.

TABLE I
IMPACT OF THE SIGNAL WITH DIFFERENT DURATION

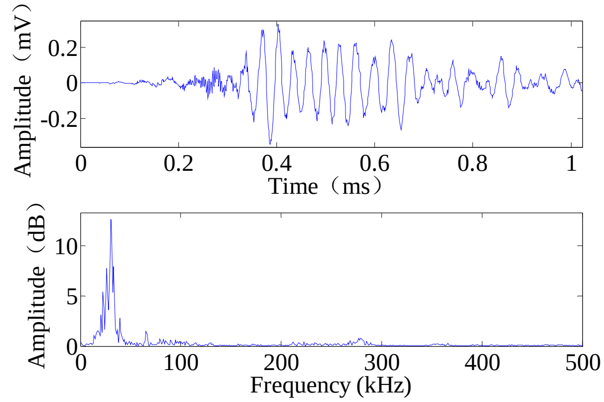
Loading Current (A)	800A			1300A		
Duration (us)	200	300	500	200	300	500
Signal Peak (mV)	0.23	0.19	0.23	0.32	0.38	0.35
Total Energy	4.08	4.06	4.82	5.51	6.77	9.64

D. *Influence of specimen type on the signals*

Through the analysis of the time-frequency characteristic of EMAE signals, the signal of the cracked specimen is different from the intact specimen as in Fig. 5. The acquired signals from the 1# specimen have the typical characteristics of AE signals that they contain high frequency part above 100kHz [6], [7].



（a）1# specimen



（b）2# specimen

Fig.5. 800A-current loading on the different samples

V. CONCLUSION

Electromagnetic acoustic emission (EMAE) technique did nondestructive detection with the effect of dynamic electromagnetic loading to generate a stress field stimulating stress waves from the defects. Through analyzing the EMAE mechanism, the finite element model (FEM) was set up. The simulation results were in reasonable agreements with the experimental results. We found that it was possible to detect whether the metal plate had crack. This work laid a good foundation for the engineering application of EMAE.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

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