Approach to Acoustic Emission Signal Analysis - Theory and Experiment

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Acoustic Emission (AE) signals are notorious for their complexity and irreproducibility. Because AE source characteristics are virtually unknown and because the detected AE signals are colored by the propagation media, the sensor response and the instrumentation settings, interpretations of test results such as spectral analysis or correlation studies are mostly qualitative and sometimes controversial; theories either are empirically derived or cannot be verified by experiments. In this paper, we sketch an approach to the AE signal analysis problem. We first report the development of a theory which allows the computation of the displacement as a function of time at an arbitrary point on an infinite plate due to an arbitrary point source force function. The theory is based on a new Fourier inversion technique which yields exact formulas similar to those developed for seismological "ray" theories. We then report experimental results obtained on a 2.52 cm thick aluminum plate using a reproducible step function stress release pulse as a simulated AE signal and a wide band displacement capacitive transducer as a sensor. The measurements are in quantitative agreement with the predictions of theory. We also discuss applications wherein the simulated signal, capacitive transducer and plate theory are used for AE source signature analysis, and sensor calibration problems.
Figure 4. Theory

Figure 5

Figure 6

Figure 7
SITUATED 1000 FEET
A MID PLATE.

A CAPACITIVE TRANSDUCER MEASURES THE TRUE DISPLACEMENT OF THE PLATE.

Figure 8. Experimental arrangement

A SIMULATED SOURCE
A STATICALLY LOADED PLATE RELEASE STEP-FUNCTION-LIKE STRESS PULSE
PRODUCED BY BREAKING LIQUID CAPILLARILY OR PRODUCED BY A MECHANICAL
DEVICE AS SHOWN IN THE FIGURE. THE SOURCE CHARACTERISTICS CAN BE
CONTROLLABLE AND REPRODUCIBLE.

Figure 9. Capacitive transducer

A SIMULATED SOURCE
A SIMULATED SOURCE OF THE ACOUSTIC EMISSION SOURCE. THE SOURCE
CHARACTERISTICS CAN BE ACHIEVED BY REPLACING THE ACOUSTIC EMISSION
SIMULATOR WITH THE SIMULATOR AND USING TRANSFER FUNCTION ANALYSIS.

Figure 10. Acoustic emission source

Figure 11. Acoustic emission simulator

A SIMULATED SOURCE
A SIMULATED SOURCE OF THE ACOUSTIC EMISSION SOURCE. THE SOURCE
CHARACTERISTICS CAN BE ACHIEVED BY REPLACING THE ACOUSTIC EMISSION
SIMULATOR WITH THE SIMULATOR AND USING TRANSFER FUNCTION ANALYSIS.

Figure 12. Results

Figure 13. Simulated acoustic emission
Figure 14. Acoustic emission characterizations