Measuring Ultrasonic Acoustic Velocity in a Thin Sheet of Graphite Epoxy Composite

Spaceport/Range Situational Awareness

A method for measuring the acoustic velocity in a thin sheet of a graphite epoxy composite (GEC) material was investigated. This method uses two identical acoustic-emission (AE) sensors, one to transmit and one to receive. The delay time as a function of distance between sensors determines a bulk velocity. A lightweight fixture (balsa wood in the current implementation) provides a consistent method of positioning the sensors, thus providing multiple measurements of the time delay between sensors at different known distances. A linear fit to separation, x, versus delay time, t, will yield an estimate of the velocity from the slope of the line.

Figure 1 shows the test jig used to align the AE transducers for the velocity measurements. The transmitting and receiving sensors are identical. The transducer on the left is the excitation transducer (transmitter) and the transducer on the right is the receiver. Both transducers are model WD wideband AE sensors manufactured by Physical Acoustics Corporation. A small amount of vacuum grease couples the AE sensors to the GEC surface. Removing the jig before a measurement is recorded minimizes the effect of test fixture loading and coupling. After each set of measurements, the grease is removed with an industrial wipe soaked in isopropyl alcohol.

The excitation signal is generated from a 5-V, peak-to-peak, 360-kHz, sinusoidal pulse composed of eight full cycles. The oscilloscope top trace, on the left of Figure 2, shows the transmitted signal and a typical received signal on the bottom. Pulse data for six distances (2, 4, 6, 8, 10, and 12 cm) is recorded, with the oscilloscope sampling average set to eight sweeps in order to remove the majority of the random noise from the AE sensor signal. Figure 3 shows an example of all received pulses for two sets of runs of a GEC sample material. When the delay times, as a function of Δx are plotted (shown in Figure 4), a linear fit yields an estimate of the acoustic velocity as the slope of the curve.

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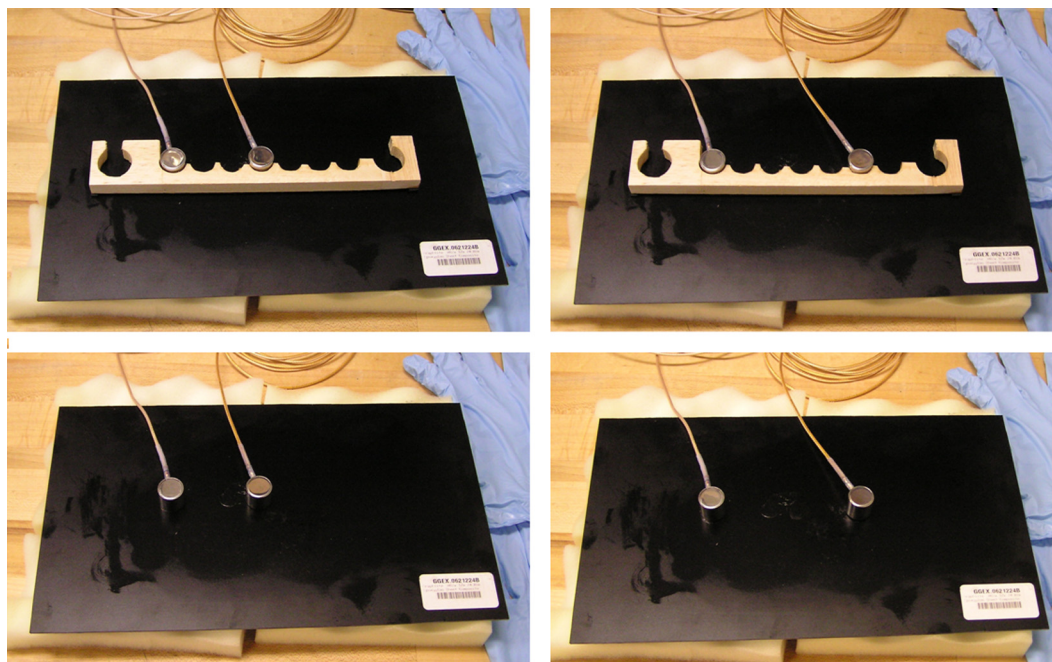
Figure 1. Ultrasonic Acoustic-Velocity Test: 6-cm separation (left); 10-cm separation (right). Top shows alignment with jig; bottom is signal measurement configuration.
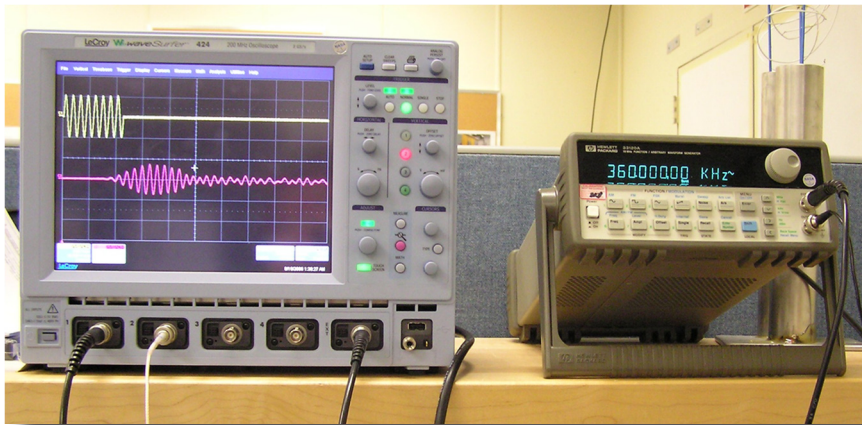
Figure 2. Signal generator (right) and oscilloscope (left): excitation signal (yellow trace) and received signal (pink trace).
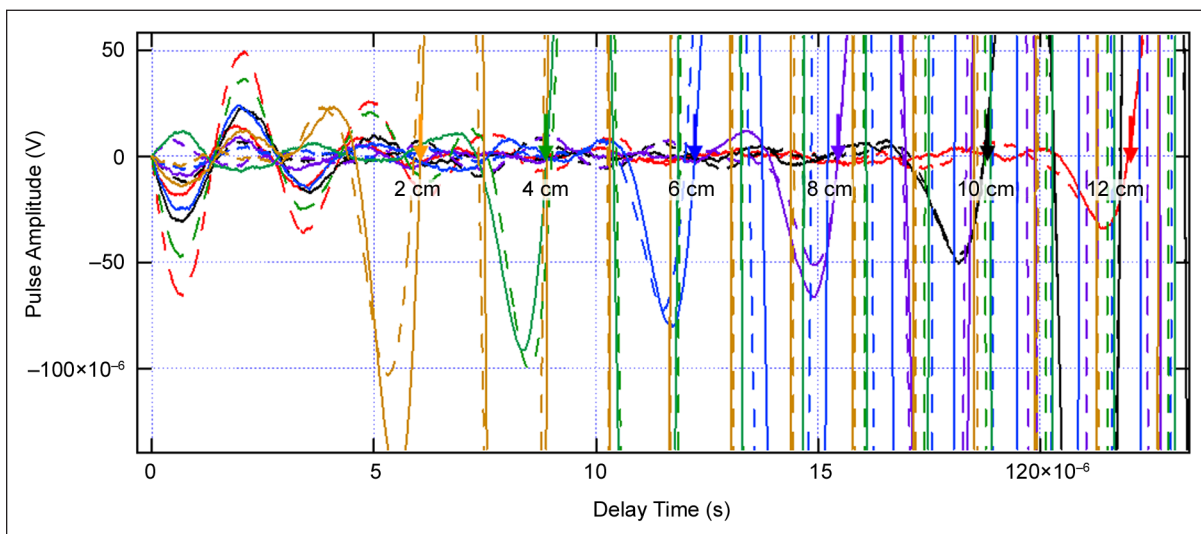

Figure 3. The first major zero crossing from negative to positive provides the delay time of the received signal. Each color represents a different separation of transmitter and receiver. Solid line is the first run; dotted line is a second run.
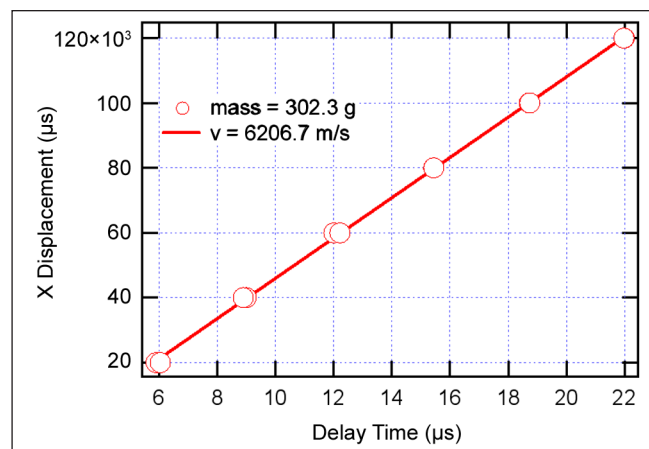

Figure 4. Delay times from Figure 3. Slope of x versus t provides an estimate of acoustic velocity.