The Study of Elastic Properties with the Use of EMAT

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Introduction

The role of electromagnetic acoustic transducers in the study of elasticity is the creation of ultrasonic waves, which propagate through materials. Elastic constants can be calculated from known material density and measured ultrasound velocity. In June/July 2005, we measured ultrasonic velocities and studied signal attenuation in four isotropic samples: aluminum, stainless steel, and two brass samples.

Experimental Findings

We made our first attempt at observing an ultrasonic signal by an EMAT employing two handmade copper-wire coils and two permanent magnets. We failed to observe any ultrasound when sweeping from frequencies 9 kHz to several MHz. (Replacing the handmade coils with machine-cut coils made little difference. We suspect that impedance-matching between the generator and the EMAT may have yielded a detectable signal.) In another attempt, machine-cut coils were inserted with a sample into magnetic fields up to 31 T in strength. A strong signal was observed in all four samples, with greater velocities and greater signal amplitudes at higher Tesla. Velocities in the two brass samples were found to be very close in value when the samples were in near equivalent field strength: the sample of length 20.626 mm had ultrasonic velocity $2.0385705 \times 10^5 \pm 4.317497 \times 10^4$ cm/sec at 15 T, while the sample of length 6.25 mm had velocity $2.0905674 \times 10^5 \pm 4.084839 \times 10^3$ cm/sec at 14 T. Velocity in the aluminum was found between $3.1268227 \times 10^5 \pm 5.049343 \times 10^3$ cm/sec and $3.1804348 \times 10^5 \pm 5.454721 \times 10^3$ cm/sec, while the stainless steel revealed an ultrasonic velocity range of $3.0251346 \times 10^5 \pm 6.760114 \times 10^3$ cm/sec to $3.174953 \times 10^5 \pm 2.127991 \times 10^3$ cm/sec. For each signal, the amplitude of peaks decreased exponentially as expected. Attenuation data was successfully calculated for aluminum and the brass plate via regression analysis. Regarding the relationship between amplitude and field strength, we observed the amplitude of specific peaks to be linearly dependent on magnetic field strength.

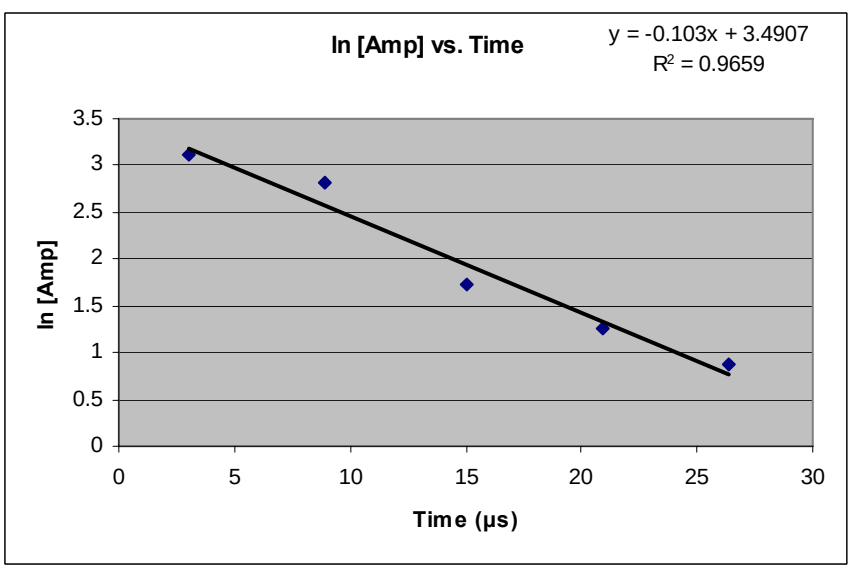

Fig.1.Regression analysis on amplitude of signal peaks of the brass plate @ 22 T

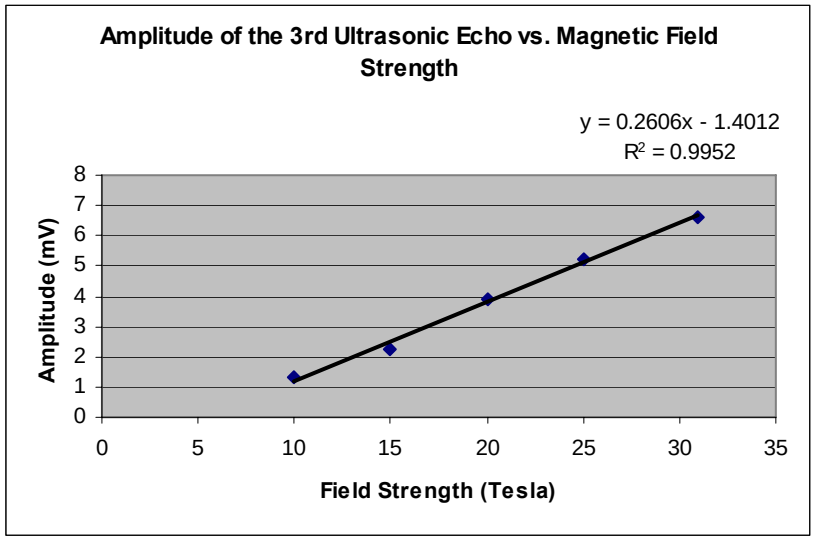

Fig.2. Field dependence of the 3rd ultrasonic echo amplitude in aluminum