Simultaneous measurement of ultrasonic velocity and attenuation loss: A frequency domain algorithm for improving accuracy

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Ultrasonic velocities of minerals are important information to understand the earth's interior. In order to improve accuracy of the velocity measurements, I devise a new algorithm to eliminate error owing to bond, which has been used to enhance ultrasonic pulse transmission from buffer rod to sample. As bond has a finite thickness of a few micron meters, multiple reverberations at both end of bond have been the major source of error in ultrasonic travel time. A new analyzing algorithm is developed for ultrasonic velocity measurement in order to eliminate the effect of bond. The procedure of the present analysis is as follows:

(1)The first and second pulses from sample are measured by using digitized oscilloscope.
(2)Fourier analysis is applied for each pulse separately. The phase difference corresponds to time difference of the two pulses, or travel time of sound wave in sample.
(3)The bond effect correction is applied for quotients between the Fourier coefficients of those two pulses. Acoustic properties of bond agent were measured separately by using reflectivity measurement.
(4)The optimized travel time is determined by adjusting bond thickness and attenuation loss in sample. In this way, we can determine acoustic velocity and attenuation loss simultaneously.

The analytical algorithm is examined by a test measurement: Sample is ordinary glass plate of 1.23mm thickness; bond agent is SWC couplant (Panametorics Co.); transducer is for 20MHz shear wave. From the reflectivity measurement, acoustic properties of SWC couplant was fixed at Vs=1100m/s and Q=5 for 20 MHz shear wave. The thickness of bond was between 5 and 6 micrometers. The resulted travel time of sample is 728.8(7) nsec and Q~500. The Q value obtained in this analysis is consistent with literature data for soda glass. In the present measured data, simple pulse echo overlap is optimized at around 724 nsec. Thus the new algorithm succeeds to eliminate the bond effect as much as ~5 nsec. Although the reproducibility of travel time is ~0.1 % at the present, effort continues to improve it at least with one order of magnitude.