Inversion of acoustic nonlinearity parameter of solid using immersion method

Yoganandh Madhuranthakam, Daniel J Barnard, Sunil Kishore Chakrapani

Abstract:

The emerging nonlinear ultrasonic methods can detect nonlinearity and micro-defects in materials, meeting critical health monitoring requirements in safety-critical industries such as aerospace, nuclear, and medicine. The acoustic nonlinearity parameter β is a crucial metric for characterizing materials, as it offers information on third-order elastic constants, dislocations, precipitates, microcracks, etc. This work employs the immersion ultrasonic method due to its advantages in calibration and scanning for calculating β. In this technique, an acoustic wave propagates through three layers (water-specimen-water) from transmitter to receiver. The measured fundamental and second harmonic pressures yield a combined β for all three layers. To calculate β specifically for the solid layer, a theoretical model of nonlinear wave propagation based on the KZK equation is developed. Finally, an inversion technique is developed to measure the β of the solid using immersion test results and the theoretical model. The β values obtained for aluminum and fused silica using this technique are in good agreement with the literature.