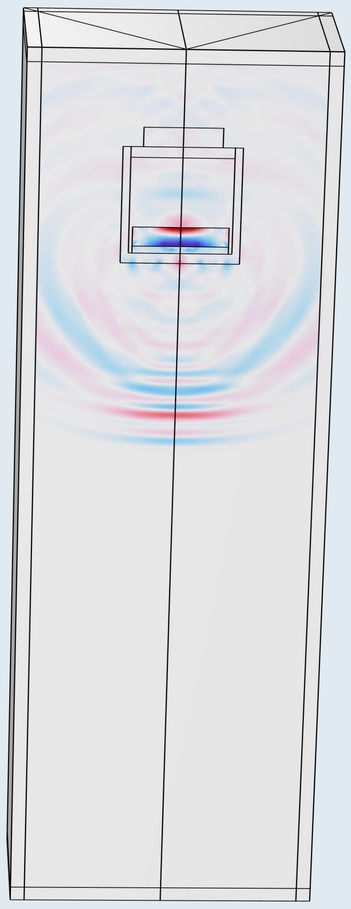

3D Ultrasonic Simulations for Pulse Echo and Pitch Catch Testing

This study employs advanced computational modeling to simulate ultrasonic wave propagation in pulse echo and pitch catch testing, providing a cost-effective alternative to physical prototyping.

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Abstract

Ultrasonic nondestructive testing (NDT) is extensively used in fields like medicine, oil and gas, and aerospace to inspect materials without causing damage. However, developing experimental setups and prototypes can be costly and time-consuming. This study employs advanced computational modeling to simulate ultrasonic wave propagation, providing a cost-effective alternative to physical prototyping. A COMSOL 3D multiphysics model is utilized to simulate ultrasonic acoustic transducers in a water tank. The model couples a piezoelectric transducer with an elastic wave model via a piezoelectric effect coupling module. The interaction between the acoustic wave in the elastic medium and the fluid is modeled using an acoustic-structure boundary coupling. Simulation results are compared with experimental to validate the model. This comparison helps understand the impact of frequency, material properties, and piezoelectric transducer design on acoustic wave propagation, reducing the need for extensive physical prototyping and thereby cutting costs and improving efficiency.

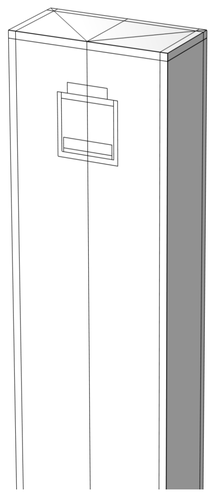


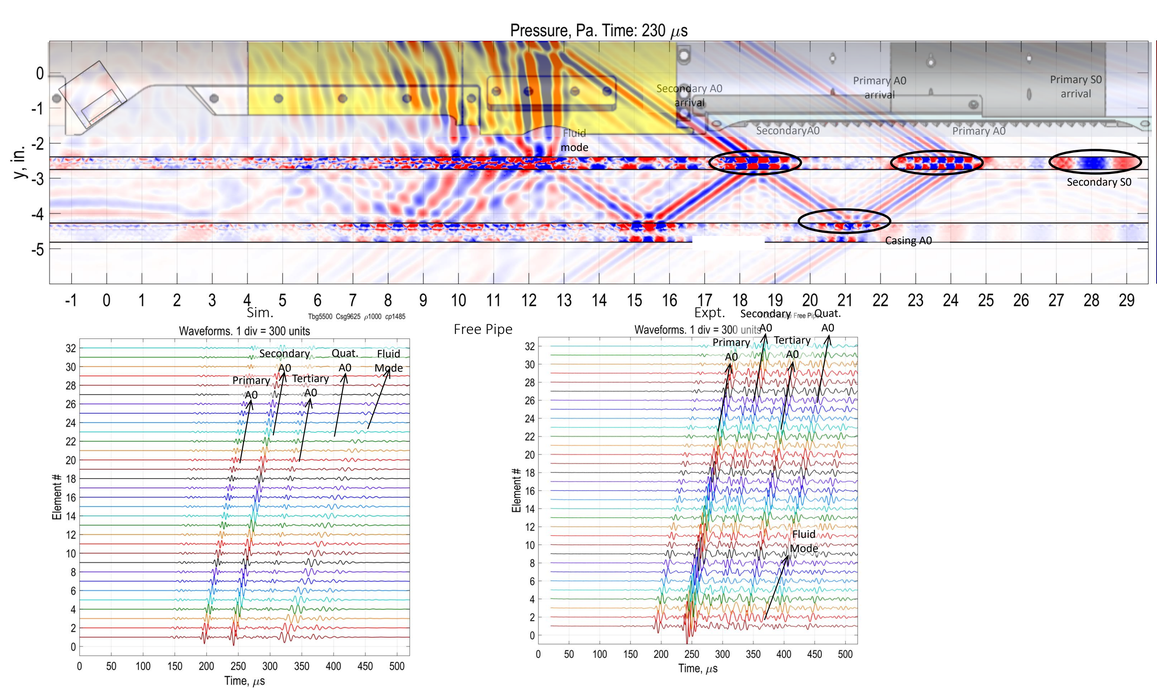
Figure 1. Piezoelectric transducer coupled to fluid

Methodology

- Electrostatics module (es) is coupled to the Elastic Waves, Time Explicit (elte) module to transform voltage signal to elastic wave.
- Elastic Waves, Time Explicit (elte) module is coupled to Pressure Acoustics, Time Explicit (pate) module to model fluid-structural interaction at the transducer's boundary.
- An external electrical circuit is coupled to the terminal of the piezoelectric element.
- Symmetric boundary condition is applied to reduce simulation time

Results

- In this study, ultrasonic piezoelectric transducers are coupled to the fluid to study acoustic wave propagation in pulse-echo and pitch catch simulation.
- The model can be used to characterize the wave propagation of different modes.
- Overall, COMSOL model simulations are capable to capture the experimental response. With good tuning, the model can be used to develop transducers and test setups to reduce prototyping cost.



Pitch catch wave propagation and waveform

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