Study & Modeling of 'Acoustic Matching Layers' for Ultrasound Imaging Probes Through Pulse-Echo FEM Simulation

L. Spicci[1]

[1]Esaote SpA, Florence, Italy

Abstract

Ultrasound Imaging probes are specific devices that require a very detailed design of acoustic impedance match for the stack of layers that form the probe head (1,3). These are typically made of silicone rubber, special epoxy resins, polyurethanes and, of course, piezoelectric materials.

The acoustic impedance, measured in Rayls, have to be matched similarly to an electric circuit (2), from a high impedance power source (PZT piezomaterial) to a low impedance load (biological medium). Thus the materials in between need to be designed and characterized in terms of their acoustic properties, that are sound speed, density and acoustic impedance. On the other hand, when developing the FEM, the probe head is modeled in the Acoustic / Structure (piezoelectric) interaction module but the stack of materials should be part of the Structure domain to get the best results from the model.

This calls for a translation of acoustic properties of each material into elastic ones, such as Young modulus & Poisson ratio, as these are not easily measurable. Equations can be found in literature for such conversion (4), but a deeper study and comparison with measurements are needed to achieve a fully functional FEM.

Both Longitudinal and Shear velocities were measured for all matching layer materials and their elastic properties were calculated. Finally, a Pulse-echo equivalent FEM was developed and validated through comparison with measurements.

The final result is a probe design procedure that allows to use acoustic measurement results for matching layers into an Acoustic-Piezoelectric interaction FEM, with intermediate conversion of material data from acoustic to elastic.

Reference

1. 'Ultrasound Piezo-Disk Transducer Model for Material Parameter Optimization', Comsol Conference 2010 , Paris

2. 'Design and Optimization of a High Performance Ultrasound Imaging Probe Through FEM and KLM Models' , Comsol Conference 2011 , Stuttgart

3. 'FEM simulation for pulse-echo performances of an ultrasound imaging linear probe', Comsol Conference 2013 , Rotterdam

4. Olympus Ultrasonic Transducers Technical Notes, page 46, eq.15&16

Figures used in the abstract

Figure 1: Acoustic impedance match.

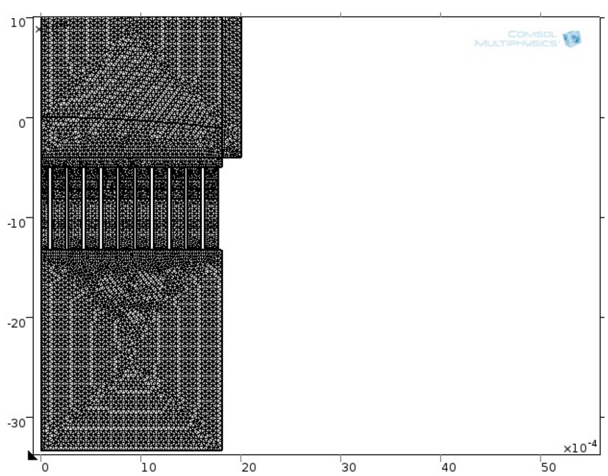

Figure 2: FEM mesh, array transducer.

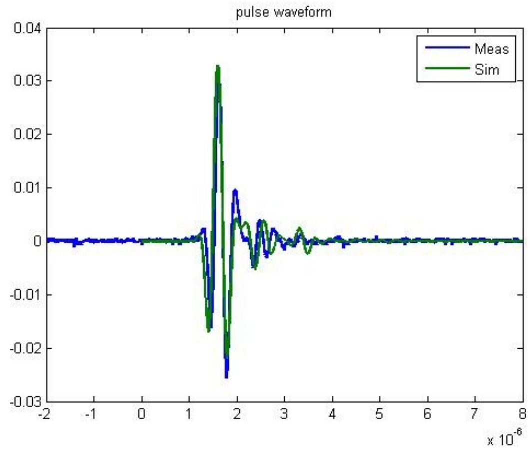

Figure 3: Agreement of simulation results and measurements.