Understanding Logging-While-Drilling Transducers with COMSOL Multiphysics® Software

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Abstract

Though wireline logging provides a significant part of the information needed for borehole drilling in the oil and natural gas industry, logging-while-drilling (LWD) tools have some irreplaceable advantages over wireline logging. They can obtain almost-real-time information on rock formation mechanics through slowness measurements and these data can be interpreted for rock porosity (which can be an indication of replenishable oil reserve), adjusting mud weight for safe operations, etc. [1]

LWD acoustic transmitter generates acoustic waves and depending on the specific rock formations, compressional, shear, or Stoneley waves can propagate along the borehole. They then are received by the receivers and since they have different speeds, they arrive at different times and show their respective slowness. [2]

One issue here is that waves also propagate along the drill and this affects the interpretation of the borehole arriving waves. A common approach is to engineer the drill with grooves so that there is a band where for certain frequencies, waves are much attenuated along the drill. To match this drill, normally a unique design of transmitter is desired so that it features resonance peaks in the drill attenuation band. This is a challenging task as without good design, the transmitter can easily have peaks outside the drill attenuation band as well.

With COMSOL Multiphysics® software, different designs can be attempted and simulated so it makes a worthy tool for LWD acoustic transmitter design. For one drill with an attenuation band of 10-15 kHz, the current design has a haunting 8 kHz peak (caused by resonance in the height direction) and other smaller peaks which render the bandwidth of the major peak narrow after filtering. The resonance frequency response is shown in Figure 1. Our new design consists of three single transmitters, each transmitter having four tapered pieces of PZT-5A ceramics. Between two single transmitters is a 10 mm thick rubber ring to reduce resonance in the height direction. Among the three single transmitters, each one is rotated 60° with respect to each other. The tapered pieces are designed to broaden the spectrum, and a total of 12 pieces of PZT will increase the acoustic power. The rotation ensures that the overall directivity is good. The resonance frequency response is shown in Figure 2 and it is a nice wideband response from 13 kHz to 16 kHz and the 8 kHz peak is eliminated completely.

Reference

1. J. L. Arroyo Franco, et al., Sonic Investigation In and Around the Borehole, Oilfield Review, Spring, 14-33 (2006).

2. Jeff Alford, et al., Sonic Logging While Drilling - Shear Answers, Oilfield Review, Spring, 4-15 (2012).

Figures used in the abstract

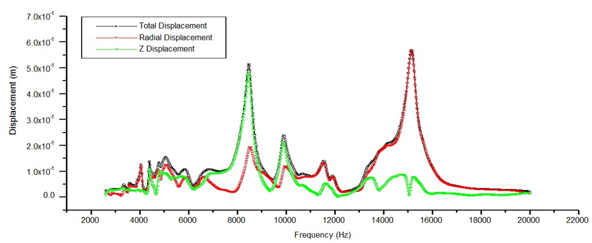

Figure 1: Resonance frequency response of the current design.

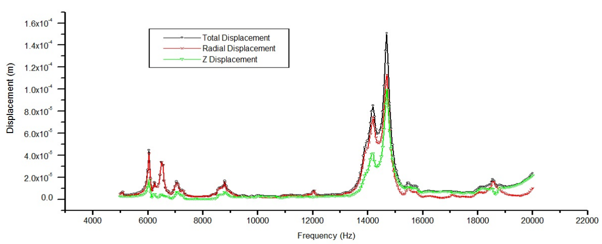

Figure 2: Resonance frequency response of the finalized design.