Development of a Low Frequency Collimated Acoustic Beam for Borehole Integrity Monitoring

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Background, Motivation and Objective

Several different industries share the common feature of a borehole for 'reaching' underground areas of interest, either for the purpose of energy extraction, e.g. oil&gas and geothermal industry, or for storage purposes, e.g. CO_2 sequestration and nuclear materials repositories. Real-time, in-situ measurements, with high spatial resolution (sub-cm) imaging of the near-borehole environment can lead to a better and quicker understanding of the near-wellbore environment. The objective of the presented work is the development of a more robust ability to image the near-borehole and to reliably detect defects in the casing, casing-cement interface, cement-formation interface, and out in the rock formation.

Statement of Contribution/Methods

Typical ultrasonic imaging tools use high frequency transducers to monitor the stability of boreholes. High frequency can successfully evaluate metal casing but cannot image deeper into cement or the geologic formation beyond the casing wall. We developed a low frequency acoustic source that can generate a highly collimated, powerful sound beam. The resulting source can operate at low frequencies of 10–250 kHz, and it is based on the vibrations of radial modes of a transducer that is clamped around its circumference. The clamping leads to altered boundary conditions that lead to tighter collimation of the acoustic beam.

Results/Discussion

We built and experimentally validated a low frequency collimated acoustic source based on vibrations of the radial modes of a transducer. It was shown that beam collimation is maintained after passing through an inhomogeneous scattering medium and we demonstrated imaging capabilities of the system, in both open- and cased-borehole, for different induced defects, e.g. groove, detachment, fluid-filled void pocket, casing. Results will be presented for selected cases, including advancements toward three-dimensional imaging in experimental boreholes in the lab.

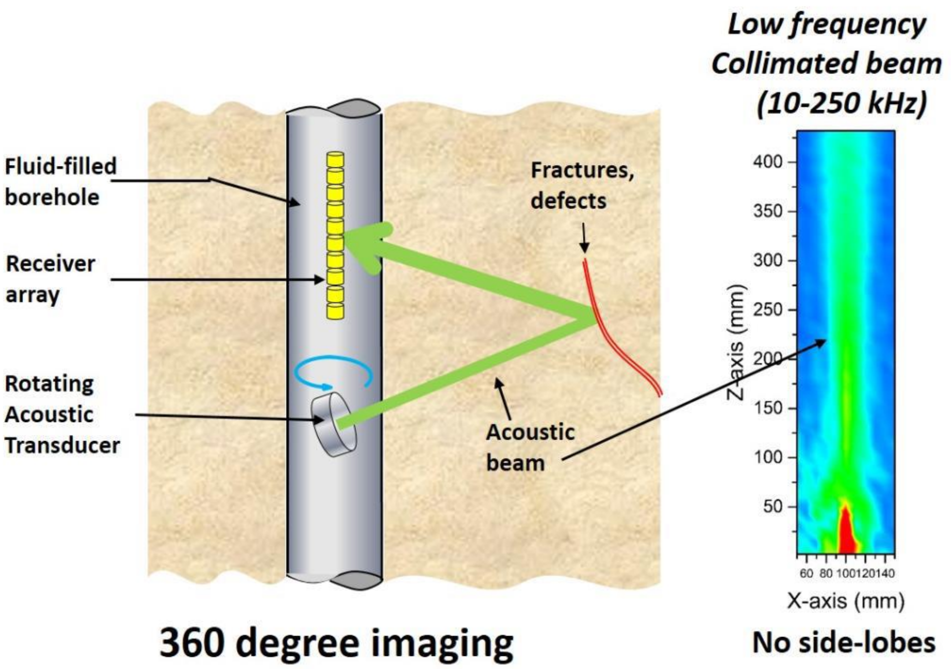

Illustration of an ultrasonic imaging system in a borehole configuration (left) and an example of a low-frequency collimated beam (right)