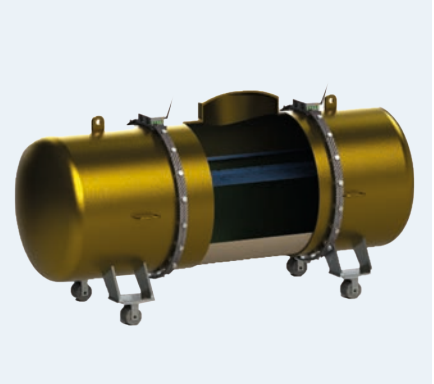

Precise online determination of vessel filling levels with guided waves

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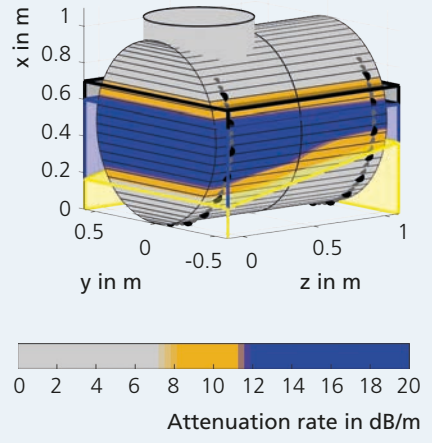
Schematic display of the measurement system as two rings around a horizontal vessel.



Graphic showing the attenuation tomographic measurements by guided waves. The color code on the outside wall refers to the measured attenuation rate, while the color code in the background refers to the real levels of oil (black), water (blue) and sand (yellow) in the vessel. The sand filling was achieved by applying a drainage textile with a tilting angle.

Knowing the precise filling levels in vessels is a common problem, particularly in the chemical industry. Such knowledge can be used to optimize processes and avoid system failures or accidents.

Continuous measurement during operation

The measurement of multi-phase filling levels often has to be performed during operation, while the vessels need to withstand high pressures and often also contain corrosive media. Furthermore, they may be subject to additional safety regulations, e.g. high-pressure tanks in the oil and gas industry, which gravitationally separate the different phases of the crude oil stream. Potential sediment build-up or rapid changes in the composition of the inflow may reduce the operating efficiency or cause undesirable and costly downtime. Reliable non-invasive online measurement could prevent this.

Most commercial level measurement techniques, such as floatings, pressure sensors, ultrasonic pulse-echo techniques, guided radar waves or capacitive measurements, are not capable of reliably measuring multi-phases and especially solid phases. Moreover, they cannot be used externally or on existing vessels without costly structural modifications. Active gamma ray methods are an exception. However, these require additional radiation protection precautions, which prevent people from entering the area. This results in high costs for the online measurement, especially on offshore platforms, which is why this method is hardly ever used for permanent monitoring in practice.

New approach for fill measurement

In contrast to the technologies described above, the solution developed at Fraunhofer IKTS is based on the use of guided elastic waves. Those are excited on the outer wall of a vessel by a scalable array of piezoelectric actuators and then measure the filling state. Along their path on the outer wall, the actively excited guided ultrasonic waves interact with the medium inside, depending on its viscoelastic properties and the excited wave mode and frequency range. Thus, a variety of measurement effects can be used and combined, the main effect is caused by an apparent attenuation through conversion to space waves and other surface waves. Finally, using a tomographic approach, a virtual image of the apparent attenuation on the outer wall can be calculated, corresponding to the contents of the vessel (attenuation tomography). The developed measurement system can be used on tanks and vessels of different geometries with and without insulation. In addition, it has an electromechanical self-testing routine, as well as the ability to detect changes in wall thickness due to corrosion and structural defects, by guided waves.

The work described here was carried out within a long-term cooperation with the company Equinor ASA.

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