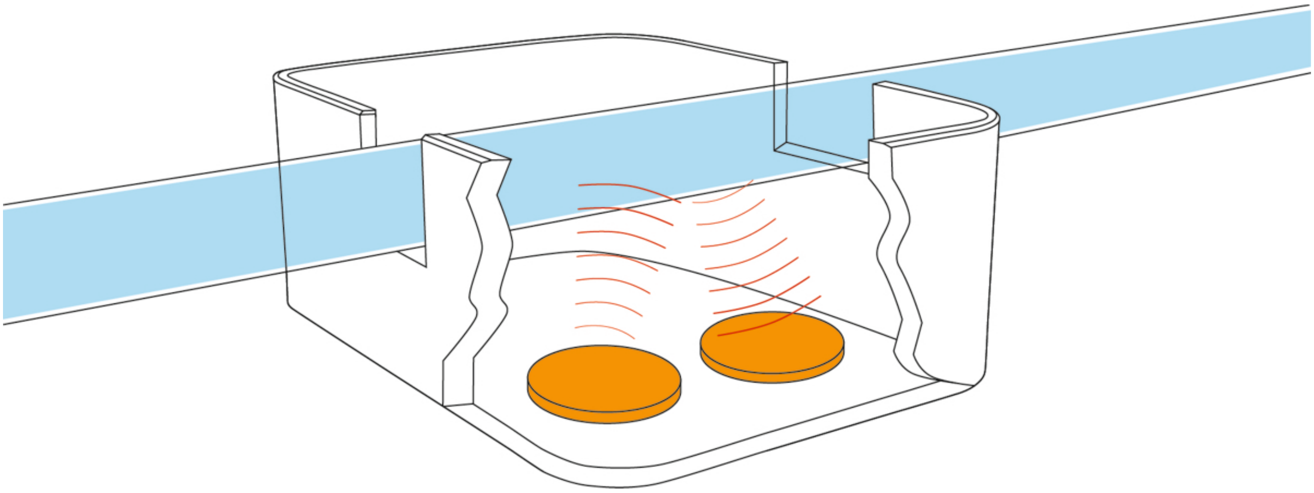
Dipl.-Phys. Birgit Schulze

Ultrasonic Sensors for Estimating Consumption in Building Services Engineering and Industry

Highly Integrated Piezo Ceramics



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So-called "static flow rate meters" with ultrasonic transducers are used, for example, in modern building services engineering for measuring the water consumption (Fig. 1). But also gas consumption can be recorded in this way. Piezoelectric components in various designs - as plates, discs, or rings - can be used as ultrasonic transducers. There are two different measuring principles for level measurement: The measurement of the propagation time or the Doppler effect.

Fig. 1 A conventional vane flow meter for recording the amount of water consumed in a household – today, the measurement of consumption and flow rate is increasingly recorded by ultrasonic sensors

In many areas, measuring the flow rate is fundamental for controlling processes. An example for this is modern building services engineering, where the consumption of water, warm water or heating energy, e.g. from long-distance heating, needs to be recorded, so that, on the one hand, the precisely consumed amount can be billed and, on the other hand, sufficient supply is ensured.

But also the metering processes in industrial automation and especially in chemical industry are very complex. Here, ultrasonic sensors are used for volume flow measurement. Instead of weighing substance quantities, a continuous volume measurement for overall process control is effected. Not only the flow velocity, but also the concentration of certain substances can be detected – this being very important for tracking chemical reactions.

In principle, even the amounts of gas can be measured with ultrasonic methods, but this is technically even more complex.

Ultrasonic Flow Rate Measurement

The propagation time measurement and the so-called Doppler effect (measurement of phase difference) are the two fundamental measurement processes in ultrasonic flow rate measurement. The piezo transducers used in each case generate ultrasonic waves which are inserted into the liquid diagonally to the direction of flow.

The measurement of the propagation time, also called the traveling principle, is based on the alternate transmission and reception of ultrasonic pulses in and against the direction of flow. Here, two piezo transducers operating as both transmitter and receiver are arranged diagonally to the direction of flow in an acoustic path (Fig. 2).

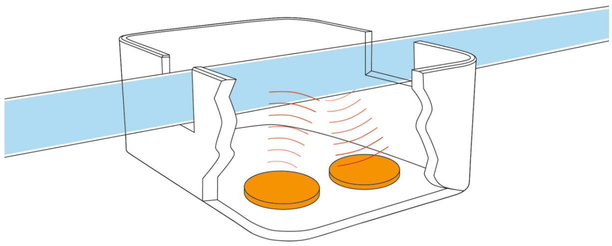

Fig. 2 Principle of propagation time measurement by ultrasound

The entrainment of the wave packet in the flowing medium (liquid or gaseous) causes a superimposition of sound propagation velocity and flow velocity. The flow velocity is proportional to the reciprocal of the difference in the propagation times in and against the direction of flow.

The Doppler effect is used to evaluate the phase and frequency shift of the ultrasonic waves which are scattered or reflected by particles of liquid (Fig. 3). The frequency shift between the reflected wavefront emitted and received by the same piezo transducer is proportional to the flow velocity.

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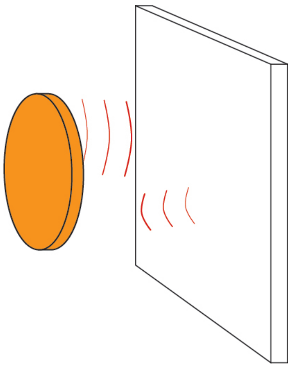

Fig. 3 Doppler effect (measurement of phase difference)

It applies to both methods that the efficiency of the measurement depends on the tube diameters and on their sound transmission characteristics.

Subsequent Installation of Measurement Devices or In-the-Flow-Measurement

Clamp-on sensors can be applied subsequently and interference-free to a an existing system. The sensor has no influence on the mass flow and does not get into contact with the flowing media, all existing tubes remain intact.

Fig. 4 Different OEM piezo ultrasonic transducers (top); bottom: piezo ceramics integrated in the sensor and equipped with electrical contacts

This is important, for example, when liquids flow at a high pressure, when they are aggressive or when special hygienic restrictions have to be fulfilled. Furthermore, there are no abrasive effects on the measuring equipment. The installation of clamp-on sensors is simple, the process is not disturbed.

Subsequently installed sensors are the ideal choice for monitoring existing systems or for effecting measurements limited in time, with low effort.

Alternatively, ultrasonic transducers can also be integrated in the flow (Fig. 5). This is especially well suited for measuring environments where the wall material has a very low sound transmission. The measuring precision of in-the-flow measurement is far above the precision of external flow measurement.

Fig. 5 Measurement cell for flow rate measurement by ultrasound (Image: Hydrometer GmbH)

Ultrasonic Sensors from PI Ceramic

PI Ceramic GmbH has established itself as a manufacturer of customized piezo ceramics for a long time now. The involvement of the customer from development to series production goes without saying whereby a great variety of geometries is possible, such as plates, discs, tubes, rings or any other arbitrary design. In this context, both the piezo components can be used both as sensors and as actuators. Also piezo elements, manufactured in large quantity for producing flow meters, are from PI Ceramic.

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What the piezo experts offer is not limited to manufacturing the piezo ceramic component for the ultrasonic transducer, PI Ceramic takes also care of its integration with the customer product. This includes both the electrical contacting of the elements according to customer requirements and the mounting of components provided by the customer, as well as the gluing or casting of the piezo ceramics. Additionally, PI Ceramic can also provide suitable electronics.

PI Ceramic is one of the world's leading companies in the field of piezo ceramics. The PICMA® multilayer actuator technology, which received an award for its reliability, is one of many innovations of PI Ceramic. Since 1992, PI Ceramic has been developing and manufacturing piezo ceramic materials and components for standard and OEM solutions: Piezo components, ultrasonic transducers, actuators, and system solutions. PI Ceramic, a subsidiary of PI (Physik Instrumente), is located in the city of Lederhose, Thuringia, Germany.

The PI Group in Brief

Over the past four decades, PI (Physik Instrumente) with headquarters in Karlsruhe, Germany, has become the leading manufacturer of nanopositioning systems with accuracies in the nanometer range. With four company sites in Germany and ten sales and service offices abroad, the privately managed company operates globally.

With 700 highly qualified employees all over the world, the PI Group is in a position to fulfill almost any requirement with regard to innovative precision motion technology. All key technologies are developed in-house. This allows the company to control every step of the process, from design right down to shipment: Precision mechanics and electronics as well as position sensors.

The required piezoceramic elements are manufactured by the subsidiary PI Ceramic in Lederhose, Germany, one of the global leaders for piezo actuator and sensor products.

PI miCos GmbH in Eschbach near Freiburg, Germany, is a specialist for positioning systems for ultrahigh vacuum applications as well as parallel-kinematic positioning systems with six degrees of freedom and customized designs.

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