Fraunhofer IPM

Magnetic flow metering enabled by quantum sensors

Non-invasive monitoring in steel pipes

Quantum sensors enable flow metering in a clamp-on fashion with high sensitivity and precision, even through metal pipes.

Flow is a crucial parameter in industrial environments and foundational for process automation. Flow measurement is an established method in production, process industry or infrastructure. Fraunhofer IPM has developed a unique procedure based on novel quantum sensors that is capable of measuring flow rates very precisely. The procedure is non-invasive, calibration-free and applicable for flow measurement even in steel pipes commonly used in industry. Utilizing the magnetic properties of the fluid to be analyzed, we aim for a multi-phase flow detection with spatial coding.

Bringing quantum sensing into process industry

In the process industry, flow metering enables consistent product quality and compliance with regulations. Accurate flow rate data is essential for controlling and optimizing processes, reducing waste and improving efficiency. Flow metering is utilized in various industries including chemical processing, food and beverage production, pharmaceutical manufacturing, as well as oil and gas processing.

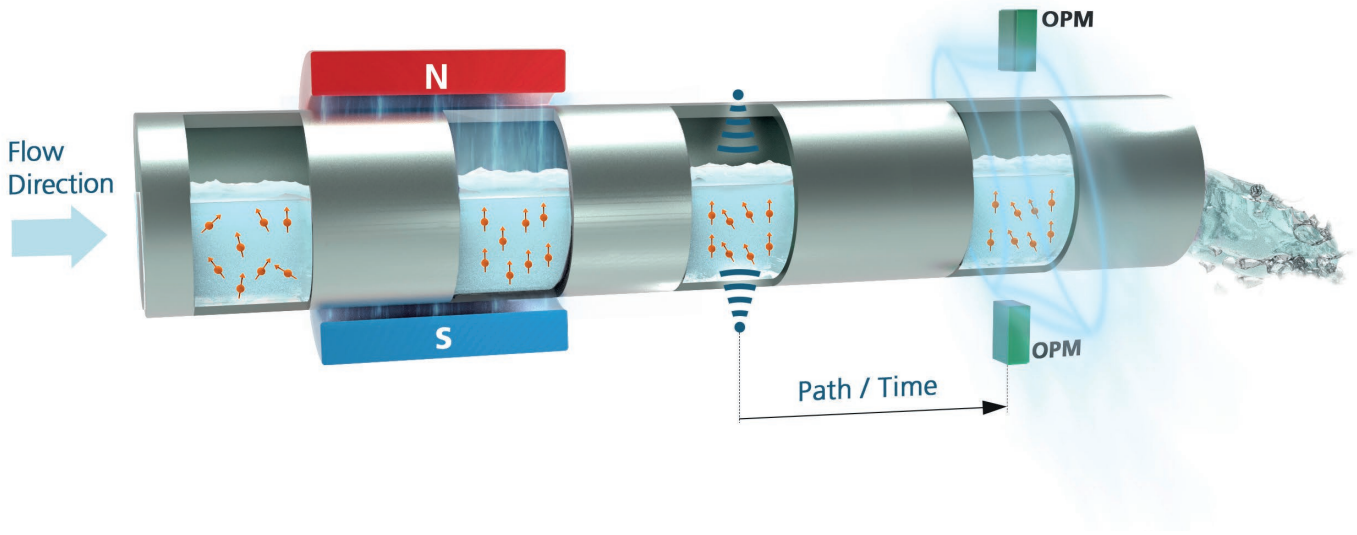
To measure the flow, the novel quantum-based procedure developed by Fraunhofer IPM utilizes the fluid's magnetic properties, which are identified by optically pumped magnetometers (OPM). OPM are quantum sensors with an unmatched magnetic sensitivity.

Optically pumped magnetometers as detectors

The magnetic flow metering procedure uses the magnetic properties of hydrogen atoms. Hydrogen is a paramagnet which can be magnetized for a couple of seconds. In a magnetized state, information such as flow velocity of the medium can be extracted from inside the pipe. To perform a magnetic flow measurement, the medium to be analyzed is magnetically polarized using a strong permanent magnet. In a second step, the

Advantages

- Non-Invasive
- Calibration-free
- Velocity range: 0.1 m/s to 3.1 or higher
- Applicable to austenitic stainless-steel pipes typically used in process industries
- Applicable to NMR active media: e.g. oils, fuels or consumer products in food, cleaning and cosmetic industries



Magnetic flow measurement procedure: Unmagnetized water is sent through a strong magnet to magnetize it. The magnetization is marked with a high-frequency pulse and read out by an optically pumped magnetometer (OPM).

background magnetization is rotated by radiofrequency pulses, creating a local magnetic timestamp. This timestamp is detected by OPMs downstream and used to perform a time-of-flight based measurement of the flow velocity. Modern OPMs are just the size of a sugar cube while at the same time being highly sensitive. Flow velocities in the range from 0.1 m/s to 3.1 m/s or higher can be detected using this method.

This novel approach to flow metering offers several advantages. As a time-of-flight based measurement, the procedure is calibration-free. The highly sensitive quantum sensors used enable non-invasive measurement of flow velocity. Thanks to the low excitation frequencies, the procedure is applicable to austenitic stainless-steel pipes typically used in process industries.

Our vision: Clamp-on pipe diagnosis tool

In developing our magnetic flow meter, we aim to capitalize on the unique strengths of the method described above. We plan to create a clamp-on detector, taking advantage of the non-invasive nature of the technology. This approach enables lower system integration costs and the potential use of the magnetic flow meter as a pipe diagnosis tool, with an OPM or other magnetometers. Additionally, the medium preparation with radiofrequency pulses allows for integration of further nuclear magnetic resonance (NMR) methods. These NRM methods include spatial coding, which allows to spatially resolve the medium flow within pipes and detect multi-phase flow.

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