Speed of sound measurements in hydrogen using a new cylindrical resonator at pressures up to 100 MPa

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For the decarbonisation of the energy sector towards net-zero emissions, a shift to a more hydrogen-based economy is inevitable. To achieve this, the different applications but also the hydrogen storage and transport will play a crucial role, in which hydrogen is present either in the liquid state at a temperature of 20 K and atmospheric pressure or as a highly compressed supercritical fluid at ambient temperatures and pressures up to 100 MPa. Within the *MetHyInfra* project, a consortium of several European metrology institutes and universities is working on metrological standards to tackle the challenges of metering and calibration of flow meters to support the continuing growth of the hydrogen industry.

An important requirement for reliable flow metering is precise knowledge of the thermophysical properties of hydrogen over wide ranges of pressure and temperature. To cover this wide range, empirical reference equations of state in form of the Helmholtz-energy functions are commonly used, and these are based on a large number of experimentally determined thermodynamic properties of the fluid. Although a reference equation of state for hydrogen currently exists [1], the number of high-quality experimental data at ambient temperatures available to be used in its development was limited. With project partners at Ruhr University Bochum (RUB, Germany) and the Physikalisch-Technische Bundesanstalt (PTB, Germany), one goal of the *MetHyInfra* project is to develop a new equation of state (RUB) based on new experimental data for the speed of sound (Imperial College London) and the virial coefficients (PTB).

In this work, a new cylindrical acoustic resonator was designed and commissioned to measure the speed of sound of hydrogen. This resonator is based on the measurement principle described by Ruffine and Trusler [2], who also developed an acoustic model to determine the speed of sound from the measured resonance frequency of an isolated mode of oscillation. The inner diameter-to-length ratio of the cylindrical cavity was chosen in a way that allows the isolation of the second longitudinal oscillation mode in the frequency spectrum. This design avoids the measuring signal being affected by radial or compound modes of oscillations. The measurements were conducted at pressures up to 100 MPa and in a temperature range between 273 K and 323 K. Since hydrogen poses significant hazards under these conditions, a carefully-designed safety system was implemented.

References

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