Burnett Apparatus for Experimental Determination of the Virial Coefficients of Hydrogen and Hydrogen-Containing Gas Mixtures

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Hydrogen and its binary mixtures play an important role in the decarbonization of the industry and energy sectors attempting to mitigate the effects of climate change. A better knowledge of their thermophysical properties is vital for more precise measurement methods, as well as the development of more refined equations of state. Currently used property data are often based on measurements dating as far back as the 1960s and is therefore in dire need of verification and update. With the Burnett technique [E. S. Burnett, *J. Appl. Mech.* **3**, A136–A140 (1936)], expansion series of a gas can be conducted to determine virial coefficients solely by measuring temperature and pressure at each expansion step. In this work, a new Burnett apparatus and an improved Burnett apparatus have been developed at HSU and PTB, respectively, to determine the virial coefficients of pure hydrogen and the hydrogen-containing binary gas mixtures H_2/CH_4, H_2/C_2H_6, H_2/N_2, and H_2/CO_2, with different molar compositions. The newly designed, robust setup at HSU consists of two measuring chambers, whereas the setup at PTB has four chambers with integrated cylindrical capacitors. This allows for the performance of parallel and complementary determinations of combined virial coefficients by dielectric-constant gas thermometry. In terms of measurement conditions, the apparatuses are designed for the temperature range from 233 K to 343 K, with pressures up to 7 MPa. The materials of the apparatus which are in contact with the gas mixtures are chosen to be compatible with hydrogen. The expansion series are fully automated by employing motor-driven and pneumatic valves, as well as nitrogen-operated pressure controllers. To maintain a low uncertainty in the pressure measurements during a measurement campaign, the absolute pressure transducers and differential pressure transducer are calibrated automatically before each expansion series with highly accurate nitrogen-operated piston gauges. Long-stem standard platinum resistance thermometers calibrated according to the ITS-90 are applied to measure the temperature. This poster presents the two Burnett apparatuses in detail and reports results of measurements.