Modified Vibrating-Wire Viscometer for Measurements of Gas Mixtures Containing Hydrogen

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A combined vibrating-wire viscometer and single-sinker densimeter [Seibt, D. Schwingdrahtviskosimeter mit integriertem Ein-Senkkörper-Dichtemessverfahren für Untersuchungen an Gasen in größeren Temperatur- und Druckbereichen. Fortschr.-Ber. VDI, Reihe 6, Nr. 571, 2008] has been modified for measurements of gas mixtures of H_2 with CH_4, C_2H_6, C_3H_8, N_2, and CO_2. It enables simultaneous density and viscosity measurements at the same state point in the temperature range from 293 K to 493 K at pressures up to 30 MPa. The density measurements are characterized by a relative expanded uncertainty (at the 0.95 confidence level) of less than 0.1%, while the relative expanded uncertainty (at the 0.95 confidence level) in viscosity is estimated to be 0.25% to 0.3%. This poster discusses the modifications of the instrument in detail and presents results of first measurements of binary mixtures of H_2 and N_2. The vibrating-wire viscometer is operated in the free-decay mode. The magnetic field in the vibrating-wire sensors, which is used to excite the vibration of the wire and to measure its free decay, is generated by two permanent magnets encapsulated by stainless steel plates. The field between the magnets was examined by simulations using the commercial software COMSOL Multiphysics ®. The results of these simulations revealed that the present design leads to a magnetic short-cut in the encapsulation. By exchanging the materials of the stainless steel plates, the short-cuts could be eliminated, which yields an improved signal-to-noise ratio for the measurement of the free decay of the vibration.

Because of hydrogen embrittlement, measurements of hydrogen-containing mixtures impose strong requirements on the materials for the parts of the instruments which are in contact with the mixture. To meet these requirements, the material of the vibrating-wire sensors had to be replaced by a hydrogen-compatible material. Moreover, since the copper-beryllium alloy of the pressure vessel could not be qualified as a certified material for pressure vessels for use in the EU at present, the outer stage of the two-stage thermostat, the double-mantle thermostat, which surrounds the pressure vessel, is employed as shatter protection. This required a redesign of the double-mantle thermostat. Furthermore, the automation of the measurements was improved by employing a nitrogen-operated highly accurate pressure controller. The measured gas is separated from the absolute pressure transducers by a differential pressure transducer with a gold-plated membrane. The pressure controller automatically adjusts the pressure in the nitrogen-filled branch of the valve system between the differential pressure and absolute pressure transducers after reducing the pressure of the gas in the pressure vessel.