Very Accurate Fluid-Density Measurement in Wide Ranges of Temperature and Pressure by Means of a Magnetic Levitation Technique

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With the goal of measuring standard reference data for the *PVT*-properties of fluids, we have investigated the hydrostatic weighing method with a magnetic levitation technique for more accurate density measurement. The hydrostatic weighing method is based on Archimedes' principle, so the density of a sample fluid is determined by measuring the buoyancy force acting on a sinker immersed in the fluid. If the buoyancy force is contactlessly measured through a magnetic coupling, even a compressed liquid or gas sample can be accurately measured over wide ranges of temperature and pressure. These so called magnetic-levitation densimeters with the advantages mentioned above are now commercially available, with relative uncertainty around 100×10^{-6}. The most serious contribution to the uncertainty of the densimeter is an error caused by magnetic influences from the sample fluid and the densimeter materials. We quantitatively and qualitatively investigated the error by both experiment and analysis with the Finite Element Method (FEM). In addition, correction methods for the error were proposed on the basis of the FEM results. By controlling the vertical position of the permanent magnet in the sample fluid to be identical before and after coupling the sinker, and comparing two sinkers with different densities for determination of the sample fluid density, the error can be almost perfectly corrected We have developed a prototype densimeter realizing the above correction method, and measured densities of water and *n*-tridecane for validation of the method. As a result, all the measured data well agreed with the reference densities within 10×10^{-6}, so the validity of the correction method was confirmed as well as the reliability of the apparatus. The expanded uncertainties (k = 2) for temperature, pressure, and density measurement in the present apparatus were estimated at 6 mK, (0.02 % + 0.4 kPa), and 20 ppm, respectively.