Simultaneous Measurement of Speed of Sound and Dielectric Constant for a Gas Sample

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A cylindrical acoustic-microwave cavity resonator was developed to simultaneously measure speed of sound and dielectric constant for a gas sample. Two commercially available condenser microphones, one is an acoustic transmitter and the other is a receiver, were coaxially mounted on each side end-plate of the cylindrical resonator. In addition, two antennae, which were made from a copper semi-rigid cable, were put onto each side end-plate to be flush with the inner surface wall. The sample gas is filled in the resonator, then the transmitter microphone generates an audio frequency sound signal into the resonator. The sound wave propagating in the sample gas is detected by the receiver microphone, and its amplifier and phase-shift are measured with a frequency response analyzer. Similarly, microwave resonance in the resonator is measured by antennae with a vector network analyzer. Speed of sound is obtained from measurement of the acoustic resonance frequencies in longitudinal modes; meanwhile dielectric constant is obtained from measurement of the microwave resonance frequencies in TM (transverse magnetic) modes. The dimensions of the cylindrical cavity, whose length and diameter are about 50 mm and 24 mm, respectively, were determined by measuring microwave resonance frequencies under vacuum on each measurement temperature. Argon gas was measured as a reference sample to check the validity of the present apparatus. Comparing the measurement data to the calculated values by an equation of state for Ar, it was found that the present data agreed well within 0.02 % for speed of sound and 10 ppm for dielectric constant.