An Apparatus for Measurements of the Speed of Sound in Liquids under High Pressures

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In the limit of low frequencies and low amplitudes, the speed at which sound waves propagate in a fluid is a function of its thermodynamic state only. Since the square of the speed of sound is the derivative of pressure with respect to density at constant entropy, speed-of-sound data can be useful for optimizing fundamental equations of state especially in the liquid region where thermodynamic properties depend strongly on density.

A new instrument based on the pulse-echo method is introduced for measuring the speed of sound in liquids with high accuracy over a wide range of temperatures and pressures up to 100 MPa. In this instrument, the sample liquid is enclosed in a pressure vessel, which contains the acoustic sensor. Short ultrasonic sinusoidal burst signals are sent into the sample liquid by means of an 8 MHz piezoelectric crystal mounted in the centre of the acoustic sensor at distances of 30 and 20 mm between two stainless steel reflectors. The speed of sound is obtained by two times the difference of the distances between the crystal and the two reflectors, the acoustic path length, divided by the difference of the time which the bursts need to travel these distances. The acoustic path length is determined by a calibration measurement with distilled water at 20 °C and atmospheric pressure. Corrections for the variation of the acoustic path length with pressure and temperature are applied. The time difference is extracted from the received pulse-echo pattern using a phase comparison technique originally developed at the van der Waals laboratory by Kortbeek *et al.* [Rev. Sci. Instrum., 56 (6) 1269-1273, 1985].

The pressure vessel is mounted in a circulating liquid bath thermostat, whose temperature is kept constant by a PID controller. The temperature is measured in the immediate vicinity of the pressure vessel by a calibrated Pt25 platinum resistance thermometer employing a high precision ASL F18 bridge system. Measurements of the pressure are performed by a Degrange & Huot gas pressure balance, which is coupled to the sample liquid via a membrane-type differential pressure null detector.

The apparatus was used to measure the speed of sound in distilled water and the refrigerant R365mfc. This paper will present the apparatus in detail and discuss the first measurement results.