

Ultrasonic Interferometry for Liquids

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ABSTRACT: An application of ultrasonic interferometry is proposed and investigated as a new possible technique for high-accuracy measurements. The basic principle of the proposed technique is the use of coherent running acoustic wave propagation along homogeneous liquid waveguide in the capacity of linear measuring scale. Experimental techniques employed in the present work for the measurement of physical parameters like density, ultrasonic velocity etc. and working principle of ultrasonic interferometer have been discussed. Principle of Interferometry is employed as an experimental tool.

KEYWORDS: ultrasonic, interferometer, acoustic, wave, propagation

I. INTRODUCTION

The possibility to use acoustic continuous wave for high-precision absolute spatial measurements performing with high speed. Main idea of the technique proposed is the use of coherent running acoustic wave propagation along homogeneous solid waveguide as a linear measuring scale. That is, a special kind of ultrasonic interferometry as is proposed as an application for high-precision linear and (or) angular measurement. An obvious advantage of coherent running wave interferometers as opposed to any pulse system is the possibility to provide high-accurate phase measurements with averaging over a lot of wave periods. The proposed principle is very close to optical interferometry, but it has several key advantages. First: most optical interferometric measurements are being performed in air. Index of air refraction spatial and thermal instability is limiting the accuracy by the value of 10^{-5} in any case. To perform these measurements in vacuum is not possible. Any solid or liquid waveguide is much more stable, but solid waveguides can be used only with the acoustic variant. Second: because optical waves are very short (about $1\ \mu\text{m}$) in comparison to acoustic ones, it is hardly possible to carry out optical interferometric measurement of fast-changing distance. In this case the repetition rate of interferential maximums is rather high for reliable acquisition and exact processing even for any modern electronic system. Acoustic systems are free of these problems. Third: acoustic elements and systems are much more simple and cheaper than optical ones. Systematic study of thermodynamic properties of solutions with a new type of multi-frequency ultrasonic interferometer is done for precise measurement of the velocity of sound in liquids. The path length in the cell is varied by motion of a reflector, at the electrical reaction of the cell upon the oscillator is used to fix standing wave position at a standard frequency, and their locations are determined with a suitable cathetometer. An investigation in the possible change of thermodynamic properties of mixtures and their degree of deviation from ideality has been found to be an excellent quantitative way to elicit information about molecular structure and intermolecular forces in liquid mixtures. This has given impetus to the theoretical and experimental investigation of excess thermodynamic properties of liquid mixtures. Measurement of physiochemical properties such as density and ultrasonic velocity of pure components and their binary mixtures are being increasingly used as tools for investigations of the properties of pure components and the nature of intermolecular interactions between the components of liquid mixtures. The significance reasons for the study of thermo-physical and thermodynamic properties of multi-component liquid mixtures are as follows: They provide way for studying the physical forces acting between molecules of different species. The study of liquid mixtures provides appearance of new phenomena, which are absent in pure liquids. The most interesting of these are the new types of phase equilibria, which are introduced by the variation in the promotion of the pure components. Liquid mixtures are the most direct source for studying the various parameters. The study of thermo-physical and thermodynamic properties of liquid mixtures helps in obtaining in depth knowledge about molecular interactions.

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II. EXPERIMENTAL DETAILS

Ultrasonic interferometer is a simple and direct device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium with a high degree of accuracy. A crystal controlled interferometer (Figure 1 and 2) operating frequencies ranging from 1 to 12 MHz has been used to measure the ultrasonic velocity. An Ultrasonic Interferometer is a simple and direct device to determine the ultrasonic velocity in liquid with a high degree of accuracy. In an ultrasonic interferometer, the ultrasonic waves are produced by the piezoelectric methods. At a fixed frequency variable path interferometer, the wavelength of the sound in an experimental liquid medium is measured, and from this one can calculate its velocity through that medium. The ultrasonic cell is consists of a double walled brass cell with chromium plated surfaces having a capacity of 10 ml. The double wall allows water circulation around the experimental liquid to maintain it at a known constant temperature. The micrometer scale is marked in units of 0.01 mm and has an overall length of 25 mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half wave length of sound, standing waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in the anode current of the piezoelectric generator. The high frequency generator is designed to excite the quartz crystal fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid filled in the “measuring cell”. A micrometer to observe the changes in current two controls for the purpose of sensitivity regulation and initial adjustment of the micrometer are provided on the panel of the high frequency generator.



Figure 1: Experimental setup of ultrasonic interferometer.

III. WORKING

The principle used in the measurement of velocity (is based on the accurate determination of the wavelength in the medium. Ultrasonic waves of known frequency (f) are produced by quartz crystal fixed at the bottom of the cell. These waves are reflected by a movable metallic plate kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and anode current of the generator become a maximum. If the distance is now increased or decreased and the variation is exactly one half wavelengths or multiple of it, anode current become maximum from the knowledge of wavelength.

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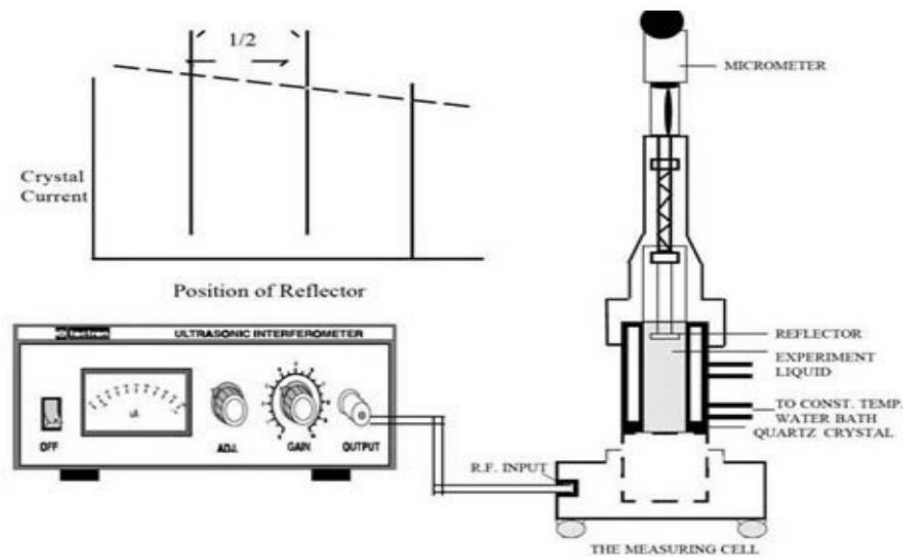


Figure 2: Longitudinal section of the ultrasonic interferometer

IV. RESULTS AND CONCLUSIONS

Ultrasonic study of liquid and liquid mixtures has gained much importance in characterizing of thermodynamic and physio-chemical aspects of ternary liquid mixtures. A variety of empirical, semi – empirical and statistical theories in liquids are available in the literature for evaluating ultrasonic velocity in liquids and liquid mixtures.

Table 1: Relationship between various parameters of the liquid and temperature

Temperature °C	Velocity in glycerine m/s	Compressibility of glycerine Cm ² /dyne	Bulk Modulus of glycerine Dyne/cm ²
32	188.44	4.4742	2.235
40	185.76	4.3478	2.300
50	1.8400	4.2658	2.3442
60	182.64	4.2030	2.3792

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The main experiment was performed with an ultrasonic interferometer within the frequency range 1 to 12 MHz. The physical properties (Table 1) of solutions were determined, such as propagation velocity, parameters like bulk modulus and compressibility. The computed acoustical parameters and their values point to the presence of specific molecular interaction when the liquid under consideration is heated in a water bath which is thermostatically controlled. There is a linearly decreasingly varying trend observed in the parameters under consideration.

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