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RESEARCHES AND CONTRIBUTIONS TO CARRY OUT A LABORATORY AREOMETER-VISCOSIMETER

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Abstract: *The laboratory equipment areometer-viscosimeter consists of a complex and performing electronic device to measure density and viscosity values of liquid materials. These two parameters are successively measured, using the same apparatus at the same temperature without requiring supplementary handling of the materials to be analyzed. The density, concentration of bi compound solutions and their viscosity are determined by an electronic device equipped with high accuracy interferometer sensor. The paper presents the experimental data obtained using this apparatus when determining glycerin density.*
Key words**:** *areometer, viscosimeter, density, viscosity*

1. INTRODUCTION

The areometer is a simple portable device used to determine the density of liquids and concentration of bi compound solutions by measuring the immersion depth of areometer tight body from the liquid to be analyzed. The main disadvantage of using areometers is low value-reading resolution with negative influence on measuring accuracy. The rheological properties of liquids are often determined by using simple devices (Bargel 2005, Atkins 2002, Schwarzl 1995) by the help of which the value of dynamic viscosity is determined, by measuring the discharge time through a calibrated hole under hydrostatic pressure of a certain volume of the liquid to be analyzed (Gutt, 2007), Despite the fact that both density and viscosity are two extremely important specific parameters for viscous flow determination, at present there are no devices performing concomitant determination (Gutt, 2009) of these two characteristics by using the same equipment and under identical conditions of temperature.

2. EXPERIMENTAL

Figure 1 and figure 2 show the basic diagram of a areometer-viscosimeter providing automate determination, high accuracy of density of pure liquids and multi compound solutions, of concentration of bi compound solutions as well as the correlation of the previously mentioned parameters to temperature and time. The same apparatus determines the viscosity of the analyzed matter while being eliminated from the density measuring cylinder. Density is determined on the basis of Archimedes' Law, by using a high accuracy laser interferometer to measure the immersion depth of a solid body from the analyzed liquid, whereas viscosity is determined by measuring the discharge time of a certain volume of the analyzed liquid through a calibrated hole. The equipment in question consists of a floating body *1*, inside of which there is a threaded extension rod *2* closed at the upper side by a metallic polished cover *3* which forms the viewing mirror of a laser interferometer sensor *4* to measure accurately the immersion level of the floating body *1* in the analyzed liquid *l* which is at its turn inside a measuring cylinder *5* open at the upper side but closed at the lower one by a taper geometry having a calibrated flow hole *o*, hole which is shut, while measuring density, by an arm *7* elastically pushed by a spring *13*. The whole structure described so far, together with a thermocouple meant for measuring the temperature of the analyzed liquid and a hand-operated mechanical system of liquid flow from the measuring cylinder after the measurements have been made, are vertically fixed on a transversal arm *16* which can be moved vertically.
Data acquisition and processing obtained from the interferometer sensor *4* and the temperature sensor *15* as well as the command of working cycles, including the liquid thermostatic control, is made by the help of a specialized soft and computer.

To increase resolution and accuracy, the apparatus has three interchangeable floating bodies, each one covering a certain density area of the range 0,50 g/cm^3 – 2,00 g/cm^3.

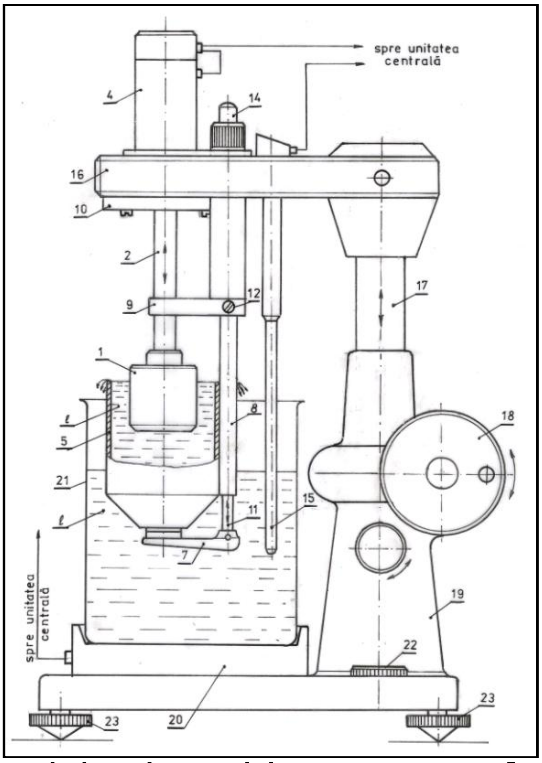

Fig. 1. The basic diagram of electronic areometer. 1- floating body, 2-extension rod 4- interferometer sensor, 5-measuring metallic cylinder, 7- shutting arm, 8- cylindrical tube , 9-lead ring, 10-holding and tightening ring, 11-cylindrical rod, 12-screw, 14-hand button , 15-thermocouple, 16-arm, 17-column, 18-hand wheel, 19- metallic frame, 20- thermostated heating system, 21-vessel with liquid to be analyzed, 22- horizontality indicator, 23- horizontality adjusting screws, *l*-analyzed liquid

The high reading resolution of interferometer laser sensors places the density measurement at the size grade of 10^{-6} g/cm^3 and the measuring accuracy at about ±10^{-5} g/cm^3, thus making the apparatus in question a means which assures performances unbeaten so far by any other density measuring device. In order to reach this performance it is obviously necessary for the measuring cylinder axis to be perfectly vertical on the free surface of liquid, therefore the measurement can be made only when the floating body does not move. Accordingly to the performances reached when density is determined, both sensitivity and accuracy increase also when concentration of bi compound solutions is determined. For example, the accuracy to determine concentration using this method is of about two size grades higher than that of bi compound solutions determined by the refractometer method, which besides requiring a more expensive logistics, allows to determine only the concentration of a bi compound solution and not its density.

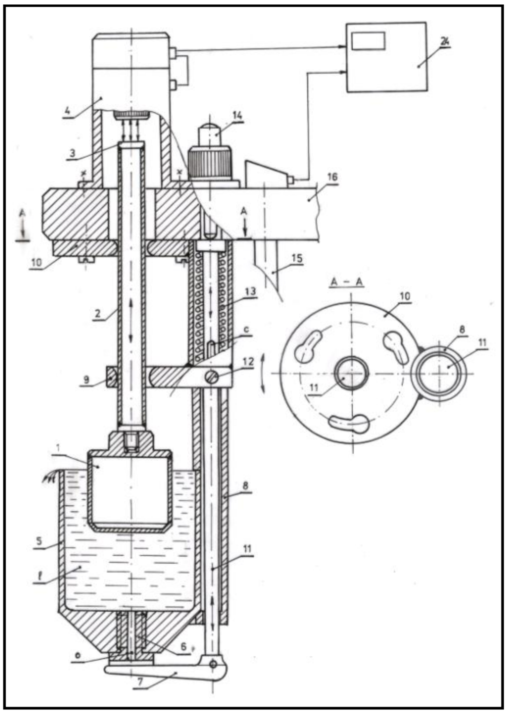

Fig. 2 Section through electronic areometer. 1-floating body, 2-extension rod 3-metallic polished cover, 4-interferometer sensor , 5-measuring metallic cylinder, 6- special nut, 7-shutting arm, 8- cylindrical tube, 9- lead ring, 10-holding and tightening ring, 11-cylindrical rod,12-screw, 13-spring, 14-hand button , 15-thermocouple, 16-arm, 24-electronic unit, *l*-liquid to be analyzed, *o*-flow hole , *c*-centering channel

Due to its simple construction, the apparatus cleaning and washing, extremely important for high accuracy determination, are easily made. A mere hand rotation of about 5^0 of the measuring cylinder *5* towards left through the cylindrical tube detaches the holding and tightening ring *10* from the transversal arm, allowing the measuring cylinder*5* to be moved down together with the floating body *1*and extension tube in view of being cleaned.

3. RESULTS AND DISCUSSION

The electronic areometer in question is an achievement of the Food Engineering Faculty team work Suceava, at the moment being a prototype. The working procedure is the following: when determining density, a vessel of *21* of the liquid *l* to be analyzed is put on the frame table *19*, the computer is turned on and the transversal arm *16* together with the whole areometer structure (fig.2) is being moved down by the hand wheel until the measuring metallic cylinder*5* is completely immersed into liquid, afterwards the over structure is lifted by operating the hand wheel *18* until the edge of the measuring cylinder is at about 1 cm above the liquid level in the vessel. The floating body *5* is immersed into the liquid from measuring cylinder at a depth in inverse ratio to density, and the liquid displaced by the floating body spills over the walls of the measuring cylinder and flows into the vessel *21*. The density measurement is automatically made only after the temperature variations measured by thermocouple and level variations caused by handling and measured by interferometer sensor are placed below a certain pre-established and acceptable level for accuracy measurements.

To measure concentration, the sequence of soft corresponding to automate conversion of the density values into concentration values for the chemical species analyzed, is being activated. When density is determined at a different value than the set one, the final correction of density value and, if necessary of the concentration too, is automatically made by extrapolating these values in electronic correcting tables of EEPROM type.

The representation of density and concentration evolution depending on temperature and/or depending on time of kinetic chemical and biological processes is made by setting on the soft sequences corresponding to those applications.

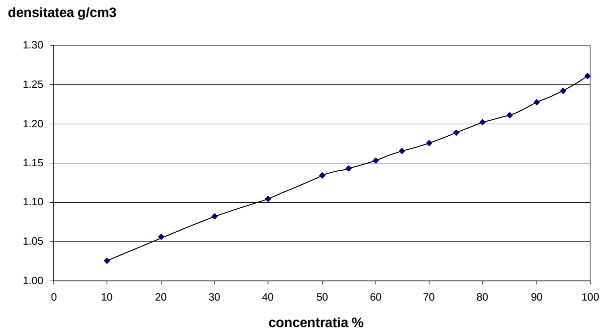

Fig. 3. Experimental data obtained after glycerin density has been determined depending on its concentration in water at the temperature of 20^0C

To determine the liquid viscosity, the liquid is poured out from the measuring cylinder *5*. With this end in view, the corresponding soft sequence is set on and the areometer is lifted to a higher quote so that the liquid from the measuring cylinder flow freely into the vessel *21*, after which the button*14* is pressed causing the liquid flow through the calibrated hole ***o*.** When a certain descending depth is reached, sensed by the interferometer laser sensor *4*, in the electronic unit *24* an electronic chronometer is automatically activated which stopping is also automatically made by the interferometer sensor when the latter one senses, by the descending distance, that the prescribed level of liquid has been reached.

4. CONCLUSIONS

By using some original constructive solutions, it is possible to design and carry out a simple and accurate areometer-viscosimeter allowing determining automatically by interferometer way the concentration of bi compound solutions as well as the concentration evolution of these solutions depending on time in processes of chemical or biological kinetics. The apparatus also allows the measurement of liquid viscosity without its further handling. The determination of all parameters in question is made under thermostatic conditions; the constructive solutions brought into discussion to carry out the laboratory equipment are simple, allowing easy cleaning and maintenance of the apparatus.

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