

INSTRUMENTS FOR MONITORING THE SPECIFIC GRAVITY OF ELECTROLYTE IN LEAD ACID STORAGE BATTERIES

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The change in the specific gravity of the sulphuric acid electrolyte in a lead acid storage battery serves to know the state of charge or the reserve capacity of the battery. Though the method of measuring the specific gravity using a float hydrometer is simple, it is cumbersome and time consuming when a large number of cells are involved. This paper reviews different approaches made by earlier workers and indicates the preliminary work carried out by the authors in this aspect.

Key words : Specific gravity monitor, lead acid battery, optical method

INTRODUCTION

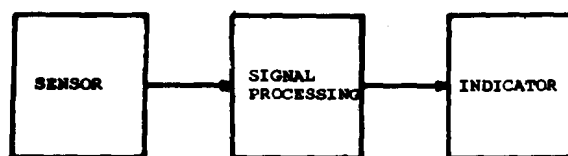
It is a known fact that one of the advantages of lead acid battery over other systems of secondary battery is that its state of charge can be determined to a fair degree of accuracy by measuring the specific gravity of the electrolyte using a float hydrometer. The specific gravity decreases more or less linearly with the electrical energy taken out from the battery. In order to maintain a lead acid storage battery in a good working condition, periodic checking of the specific gravity, followed by its adjustment either by adding distilled water or sulphuric acid is essential. When the number of cells involved are fairly large, such as in stationary applications and in train lighting systems where the cells are fitted to the undercarriage, it is a very difficult and time consuming job to monitor the specific gravity of all the cells.

Though many instruments have been developed [1-3] for measuring the changes in the specific gravity of liquids either in stationary or flow systems, these instruments could not be used in lead acid storage battery, because of limitation of space, corrosive nature of the sulphuric acid, etc. Further most of the instruments developed are bulky and not suitable for quick measurements. A portable instrument which can be handled by unskilled personnel and without removing the electrolyte from the battery is more desirable. This paper gives an account of the work carried out by different workers and also the preliminary work carried out by the authors for monitoring the specific gravity of sulphuric acid electrolyte.

The devices that have been fabricated so far for monitoring the specific gravity are based on different principles, but essentially consist of a sensor, a signal processor and a measuring device or indicator as shown in the block diagram (Fig. 1). The different types of sensors developed so far are of optical, hydrostatic, electronic, electrical or electrochemical.

Optical sensors for automatically registering the changes in the electrolyte specific gravity during charging and discharging of lead acid cells have been developed [4-11]. The basic principle involved in optical sensor is that the relationship between the specific gravity of the electrolyte and its refractive index is linear. The device, which resembles a miniature refractometer is able to plot the density of

the electrolyte in the form of graph and the accuracy is reported to be good. An electronic circuit for compensating the effect of temperature while measuring the specific gravity of the electrolyte using the optical sensing method has been reported [12].



TYPES OF SENSORS

- (1) OPTICAL
- (2) HYDROSTATIC
- (3) ELECTRICAL/ELECTROCHEMICAL
- (4) ELECTRONIC
- (5) OTHER TYPES

Fig. 1: The principles involved in devices for monitoring the specific gravity of lead acid battery electrolyte

An ingenious method [13] is reported for monitoring the specific gravity of the battery electrolyte by using an optical sensor in combination with electronic sensor. The proposed dynamic hydrometer is a float similar to the ordinary hydrometer, whose position can be continuously monitored with a capacity sensor. The advantages claimed are (i) that its functioning is independent of liquid level and the specific gravity is directly read and (ii) the instrument can be used for insitu monitoring of many chemical processes in which the refractive index is used as indicator.

A German Patent [14] described a sensor for continuous monitoring of the specific gravity using an immiscible liquid of low specific gravity which is filled at the opening end of the battery. The level of the liquid is measured by an immersed thermistor probe kept at a definite level above the electrolyte outside the tube. The electrical resistance of the thermistor indicates the immersion depth in the tube liquid due to temperature change and therefore the density of the electrolyte by a suitable calibration. Another device [15] consists of a number of floats of varying densities and a contact switch for each float. The floats rising above depending upon the specific gravity of the electrolyte establish

electrical contacts to an indicator which gives the value of the specific gravity of the electrolyte.

A method of measuring the specific gravity by the use of open vertical tube, immersed in the electrolyte containing an immiscible liquid and an electronic circuit for measuring the difference between the liquid levels has also been reported [16].

Some of the devices developed are based on electrical/electrochemical sensors. The conductivity of the electrolyte between two point electrodes dipped in electrolyte [17] or the change in potential between a fixed electrode (Pb or Pb alloy) and a float [18] with a pin which contacts with the fixed electrode have been reported. A Japanese Patent [19] describes a monitor consisting of a top closed cylinder containing a negatively charged electrode and a long cylinder having a pin hole at the bottom. The long cylinder moves up and down in the electrode cylinder according to the electrolyte density difference inside the cylinder and outside. The cylinder movement controls the contact between the electrolyte level and the electrode.

A sensor made in the form of a battery stopper containing two concentrically arranged acid resistant plastic material which is coated with dielectric layers (TiO₂) to form a capacitor has been reported [20] and the variation in the measured capacitance gives the value of specific gravity of the electrolyte.

Another device [21] consists of a spindle connected with one end of the rod, the other end of which is connected to an electric strain gauge to measure the deflection of the rod as the density changes in the electrolyte. The accuracy is claimed to be 0.0001 g/cm³.

A method based on radioactive substance, which is in fluid communication with the housing where the electrolyte is kept has been devised [22]. The backscattered radiation is counted, processed and an electrical output circuit provides a measure of the density of the electrolyte.

EXPERIMENTAL

In the present study, a probe based on optical principles has been developed which consists of a miniature light source with a colour filter. The dimension of the probe developed is 40mm x 30 mm x 40mm height. The set up employed by the authors is shown schematically in Fig. 2.

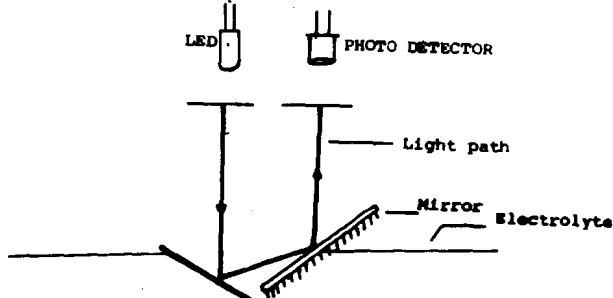


Fig. 2: Schematic diagram of the set-up used for measuring the specific gravity

The light coming out of the light source is allowed to refract through a thick glass plate whose angle can be adjusted to a desired

value with respect to the light rays falling on it. When the angle of the refracting surface is sufficient to make the light rays to suffer an internal reflection, this angle is fixed and the light rays are reflected by means of a mirror onto a photo detector (such as a photo diode or photo transistor). The output signal from the photo detector is amplified by a two stage amplifier and fed to a digital millivoltmeter. The amplifier circuit employed is shown in Fig.3. The voltage output was found to be proportional to the specific gravity of the sulphuric acid.

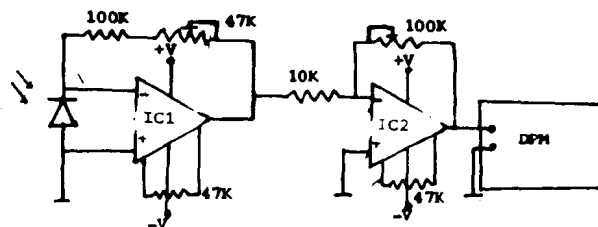


Fig. 3: The circuit diagram of the electronic amplifier used in the measurement

RESULT

The probe is dipped in sulphuric acid of different specific gravities and the output was measured using a digital voltmeter. The experiment was repeated a number of times and the values obtained were found to be fairly reproducible as shown in Fig.4. It was found that the output obtained is directly proportional to the specific gravity. As mentioned earlier, the design of the sensor influences the output signal obtained to a large extent.

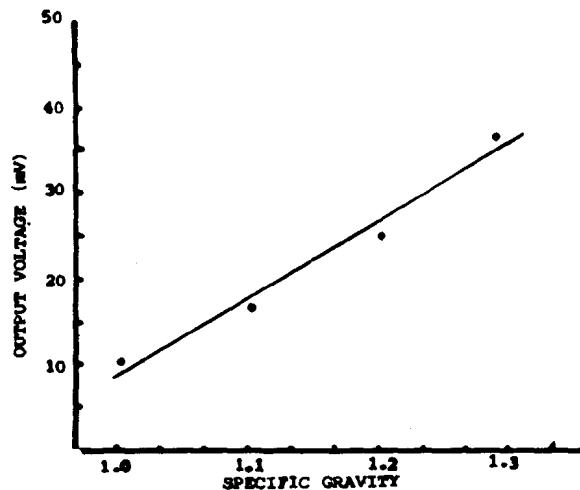


Fig. 4: The graph showing the voltage output vs specific gravity

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