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EFFECT OF POLYACRYLAMIDE GEL ELECTROLYTE ON THE PERFORMANCE OF LEAD ACID BATTERY

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ABSTRACT

Polyacrylamide gel along with fumed silica as gelling agent is investigated as electrolyte for lead acid battery. This valve-regulated lead acid technology have various advantages over flooded electrolyte system because no water maintenance, or special ventilation requirement for acid fumes and have recombinant, starved or immobilized electrolyte systems. The flooded-electrolyte batteries suffer from acid stratification due to its high density during the charging process, can sink to the bottom of the battery container, so uneven utilization of active material decrease the capacity of battery. This results in a decrease in battery capacity due to uneven utilization of the active material. Stratification of electrodes by sulphuric acid has been overcome in gel batteries because of fumed silica gel which has widespread utility. The gelling agent has three dimensional network structures so it is not precipitated in lead acid batteries during electrochemical reaction. The gel of polyacrylamide in sulphuric acid along with the fumed silica is described as electrolyte in battery which has positive effect upon efficiency and life of the battery as compared to the flooded acid battery by comparing and monitoring different parameters such as voltage-time, ampere-time relationship and charge-discharge rates.

Key words: Polyacrylamide, Battery, Silica, Voltage, Ampere.

INTRODUCTION

The lead-acid battery was invented by German scientist Sinsteden and modified by French scientist Planté, which was then commercially available and this battery is till time available in different ampere powers and is utilized in plenty of applications because it is rechargeable [1]. As it is evident that we are living in an Era of energy crisis globally and most

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of energy storage challenge is covered by flooded acid battery. After the disadvantages of this kind of battery like short life, regular maintenance, leakage of electrolyte, sedimentation at electrodes, gassing and shedding of active material, there needs to be replacement of flooded acid battery with long life battery with deep discharge outputs and high number of cycles. Gelled electrolyte batteries provide the deep discharge cycles and both work at the principle that electrolyte is immobilized in absorptive glass mat and in gels, respectively. In this manner number of cycles of a battery is augmented and so many problems of flooded acid battery are ameliorated. The most important feature of these batteries is that active material on electrodes is restored to original state as a result of repeated charging and discharging processes and less damage to electrodes, less internal resistance and separators also remain the safe thus enhancing life of battery. At present gelling technology is based upon the entrapping of sulphuric acid electrolyte in fumed silica along with additives, which renders a stable gel that is long life and environmentally safe. The stability of the gel is attributed to hydrogen bonding between negatively charged sulphate ions and positively charged particles of silica and formation of siloxane bridges between the silica particles, which leads to very strong intermolecular bonding. The interesting thing is that sulphuric acid bound by the gel insulates the electrodes as a separator[2-5].

Different gelling materials such as polypropylene microfiber, gel containing sodium silicate, silica sol, polysiloxane gel, fused silica, and polyacrylamide with oxides of alkali and alkaline earth metals has reported for lead acid batteries to enhance their performance[6-14]. In the present work much attention has been given to enhance the battery life by adding polymer (polyacrylamide) gel electrolyte in place of aqueous sulphuric acid in the cell thus preventing water loss, gassing, and stratification thus imparting the stability, reliability and high output current to the battery.

EXPERIMENTAL

Chemicals and Reagents

Sulphuric Acid (Sigma, Aldrich, USA), Lead Nitrate (Merck, Germany), Fumed Silica (Merck, Germany) and Polyacrylamide 2505 were used as polymer. Distilled Water (Double) was prepared in our own Lab using Milli Q System, USA in order to avoid the interferences of various electrolytes present in routine use.

Solution, Gel preparations and Instrumentations

Elemental standard solution of Pb (0-25 ppm) was prepared from stock solution (1000 mg/L) (Fisher Scientific, UK). High pure water was used for diluting solutions.

Atomic absorption spectrometer was used for Pb contents in plates under the optimized instrumental conditions. Briefly PG-990 atomic absorption spectrometer equipped with fully integrated atomizers that is a burner system for flame atomization equipped with a deuterium background corrector. The system was operated from an interfaced computer running AA Win Lab software. Lead hollow cathode lamps were used as line sources for analyte[15-20]. 1.7-2.3% of polymeric gel was prepared by dissolving it in sulphuric acid (30%) along with fumed silica (4%), then it was heated at a temperature of 60-70°C for 30 min and formed gel was sonicated to remove the air. This gel formed was stable and have enough capability to mobilize the ions through it. The gelling time has a strong impact upon stability homogeneity and ruggedness of gel. Then conductivity was determined by multi-meter (Orion 5 star, Thermo scientific, UK). Alpha IR spectrometer (FTIR-ATR) from Bruker, USA was used to record the IR. The battery was charged for an hour using 6 ampere current with the help of Westalite charger, Pakistan and noted the time voltage drop relation using Digital Multitester, USA device.

RESULTS AND DISCUSSION

The procedure was preparation of different gelling material from polymers is described in experimental section. The stability and shelf life of polymer gels made was also observed for the period four weeks. The polymer gel remained stable and homogenous and gel showed the conductivity of 900 µS/cm. The characterization of gel is done by FTIR, the characteristics peaks confirm the formation. 3337 cm^{-1} and 1638 cm^{-1} correspond to N-H stretching and carbonyl respectively of amide confirms the gel characteristics. The concentration of lead from scratched electrode was measured using atomic absorption spectrometer and lead concentration was found to be 90.1%. The parameters of linear regression equation are: $y = 0.0041x-0.0016$ with regression coefficient (r^2**)** obtained as 0.9988 determined the accuracy of method for Pb analysis. After charging the batteries for 70 min. at 6 amp. noted the voltage with the help of Multi Tester after intervals and established the relationship between time and voltage for both the flooded and gel batteries. The relation is presented in graphical relation is explained (Fig. 1). With passage of time drastic changes in voltage were observed in flooded acid battery as compared to gel electrolyte battery. Both the flooded and gelled electrolyte batteries were again charged up to 40 min. at 6 amp. and studied the comparative time ampere relationship (Fig. 1). As with passage of time significant changes were noted in voltage measurements while for amperes calculation up to 30 min. the amperes of both the batteries were almost same. After the passage of 30 min. the ampere drop was significant in flooded battery as compared with gel battery.

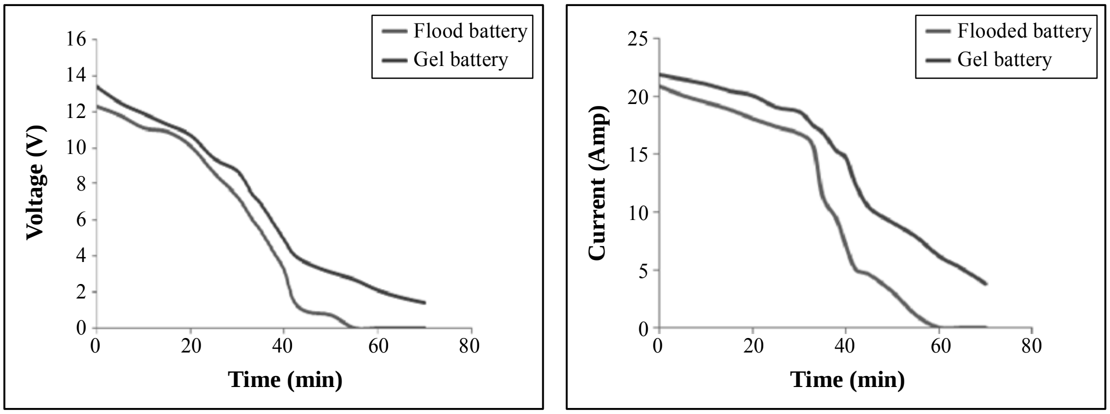

Fig. 1: Time versus voltage and current relationship

The ampere hour capacity of the battery was measured for about 1000 cycles and studied the relationship between number of cycles of the battery and ampere hour capacity. The relation is presented in graphical relation (Fig. 2). Ampere-hour capacity (Ah capacity) for gel electrolyte battery was measured upto 6000 no of cycles. There were no significant changes observed after such a large no of cycles. This Ah capacity at higher no of cycles indicated the stability of battery and uniformity of performance as compared with flooded acid battery. Simultaneous measurements of four parameters amperes and volts of the both flooded and gelled electrolyte batteries were measured after charging the batteries at 6 amp. for 40 min. and the relationship between the parameters is presented (Fig. 2). In summaries, the voltage and ampere relationship for both the flooded acid and gel batteries were drawn and it was observed that gel battery has significantly higher voltage and ampere than the flooded acid battery after 60 min. of time interval.

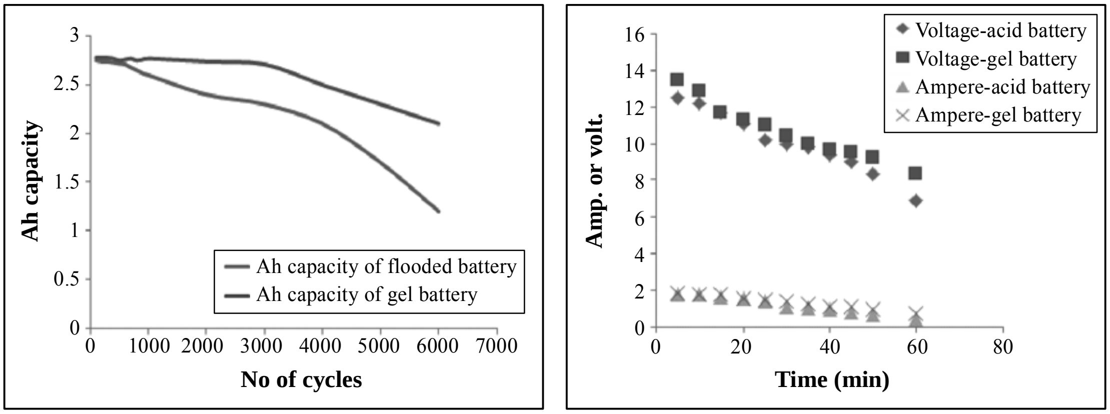

Fig. 2: Ah capacity and performance on acid and gel batteries

CONCLUSION

Our focus in the present research project was to enhance the performance of lead acid battery by using silica-mixed polyacrylamide gel in the battery. The formation of gel was confirmed by FTIR. Time-voltage and time-ampere relationship of the gel based battery was established. These relationships were compared with that of flooded lead acid battery. In comparison to flooded acid battery, it was found that gel based battery had voltage values greater than that of flooded lead acid battery. Comparison of time-ampere relationships of two batteries also showed the trend of decreasing ampere as a function of time but it was seen that at any time interval, the ampere of gel based battery exceeded the ampere values of flooded acid battery. The efficiency of gel based battery was measured in terms of ampere-hour capacity as a function number of cycles. The results revealed that even up to 6000 cycles of charging and discharging, the gel based battery showed its stability and consistency in performance. It is concluded that gel based battery showed approximately 30 % more efficient and lifespan than flooded acid battery.

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