Bulletin of Electrochemistry 15 (9-10) September-October 1999, pp 350-352

0256-1654/99/$ 3-50

COMPARATIVE STUDY ON THE UTILISATION OF ACTIVE MATERIAL IN THE CAST AND EXPANDED LEAD ALLOY NEGATIVE GRID

S AMBALAVANAN, M DEVASAHAYAM AND N VENKATAKRISHNAN

Central Electrochemical Research Institute, Karaikudi 630006, INDIA

This paper compares the performance of negative plates made from cast and expanded Pb-Ca-Sn grid alloy at different rates of discharge (current density). It has been found that at very low rate of discharge the active material utilisation of expanded grid is more whereas at high discharge rates the active material utilisation is more in the case of cast grid.

Keywords: Lead acid battery, negative grid, alloy

INTRODUCTION

One important aim in battery research is to improve the performance of a battery so as to have high energy density. This can be achieved by changing the container material and the current carrying components as well as by increasing the utilisation of the active material and electrolyte. This paper deals with one of these aspects, namely, grid design for lead acid battery.

The grid is regarded as simply an electrical conductor and by considering the spatial variation of the current density within the grid network it is shown how designs which may better employ the available metal be evolved [1]. While the electrical resistance of the electrodes in lead/acid batteries can be neglected on low-rate discharges in comparison with other resistive contributions, the minimization of electrode resistance is very important as it reduces cell voltage and inhomogeneous current distribution across the electrode plane at high rate discharge [2].

EXPERIMENTAL

The cast grids were made by conventional technique while for expanded grid, slabs were cast, rolled and punched. The sizes of both expanded and cast grids were 14 cm x 13 cm x 2.2 mm. In order to ensure uniformity in cast and expanded grid, two sets of experiments were carried out in each case. Both negative grids were made from Pb-0.07% Ca-0.03% Al. Identical cast grids were used for positive and negative made from cast and expanded grids. Four cells were assembled with two positives and one negative. The ratio of grid to active material was 1:1.09 for both cast and expanded grid. Cell numbers 1 and 2 contain two cast positive, in between one expanded negative grid and separator on both sides in each cell. In cell numbers 3 and 4, two cast positive and one cast negative and separator on both sides in between

TABLE I: Percentage of active material utilization of negative plate at various current densities (A/dm^2) for expanded/cast grids

Design of negative grid			Current density (A/dm^2)				
	0.274	1.3736	2.197	2.6098	3.0219	3.296	3.571
			Percentage of active material utilization				
Expanded							
Cell No 1	53.39	36.55	27.87	22.76	21.77	19.65	19.80
Cell No 2	53.29	37.60	27.57	22.45	22.14	18.95	18.47
Cast							
Cell No 3	44.44	32.70	26.23	21.30	23.26	18.79	18.69
Cell No 4	46.03	30.97	24.52	21.30	23.89	19.30	19.20

positive in each cell. The positive grids are made from Pb-Sb-Cd alloy. After the assembly of cell, it is subjected to discharge at different current densities in 1280 SpGr acid. The cut off voltage was 1.75 VPC.

RESULTS AND DISCUSSION

At each current density value, the utilisation of active material at the negative plate is calculated for both the grids and the result is given in Table I. Graph is drawn between current density and percentage of active material utilisation and shown in Fig. 1.

At a current density of less than 1.37 A/dm^2 the active material utilisation of negative plate with expanded grid is more than that of cast grids. As the current density value goes on increasing the utilisation of active mass is decreasing for both expanded and cast grids. However, at a current density of 2.6098 A/dm^2 onwards the trend for cast grid is increasing and reaches a maximum value at a current density of 3.0219 A/dm^2 and after this it decreases and coincides with expanded grid at current density of 3.296 A/dm^2 and remains constant. For expanded grid the percentage of active material utilisation reaches a minimum value at 3.296 A/dm^2 and remains constant.

The internal resistance of a battery is the sum of the resistance of the electronically and ionically conducting components [3]. In lead acid battery system, the active material transfers current from the electrochemical reaction sites to the supporting grid members [4]. The current then follows a path from the grid through grid lugs and straps where the currents of each of the plates in the cell are summed and carried to the intercell connectors.

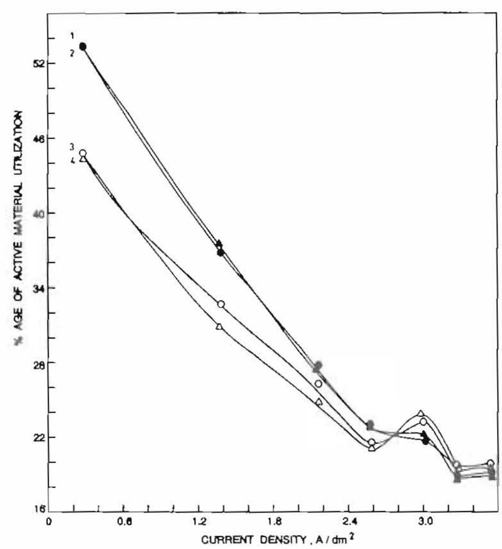

Fig. 1: Plot of percentage of active material utilization against current density

At low current density, a uniform loading of lead sulphate ($PbSO_4$) occurs in the interior of the electrodes during entire discharge. The sulphuric acid necessary for this discharge must be brought into the pore system by diffusion and migration [5]. These $PbSO_4$ crystals deposited on 'Pb' becomes larger with decreasing current density [6]. It is reported that the cast grid with take off lugs cast near the centre of grids (incorporated in our cast grid design) gives more uniform current density over the plate surface [7]. However, in the experimental observations, the coefficient use of active material in expanded grid is more than cast grid at low current density. This means that the expanded grid should have a low resistance as compared to cast grid. This could be achieved by the diamonds in the expanded grid which is relatively small to minimize the effect of less conductive paste. In addition to small diamonds, the differential width diamond increases the performance by increasing conductive capacity in the high current density areas of the grids [8].

With increasing discharge current density, finer $PbSO_4$ crystals deposit on the electrode surface causes a decrease in active material utilization. At a current density of 3.019 A/dm^2 the utilisation of active material in the cast grid is more than that of expanded grid. This result coincides with already reported expanded metal grids resulted in 18% reduction in the high rate performance for equivalent plate area to conventionally cast grids [9].

The electronic portions of the resistance to current flow with the exception of grid resistance are small amounting to 8% of the internal loss in the conventional battery designs [10]. Grid resistance alone adds 19% to the total. Ionic resistance in the electrolyte path is another 17% which leaves by difference 56% in the areas of mass transfer (concentration polarization), reaction kinetics and electrode morphology. The current distribution in the practical porous electrode is not uniform because of the mass transfer and ohmic hindrances. Since all the parameters are same, it is felt that the grid resistance alone makes this difference between cast and expanded grid. The decrease in the utilisation of active material in expanded grid may be due to non-uniformity of current density in the plate. Further, there is an optimum point at which for any particular given rate, where available pore space reaches a maximum [11].

CONCLUSIONS

The design of the grid has to play a vital role with respect to utilisation of active material. There seems to be optimum current density value where the utilisation of active material in expanded grid is low as compared with cast grid. After this optimum current density value the difference in the utilisation of active material is negligible. There is scope for further study at very high current density.

REFERENCES

1. J E Puzey and W M Orriel, *The distribution of potential over discharging lead acid battery plates*, Power Sources 2, Proceedings of 6th International Symposium held at Brighton, September 1968, 121
2. Eberhand Meissner, 'Calculation of potential distribution and voltage drop at electrodes on high rate discharge: Literature Survey and computer aided approach', *J Power Source*, **42** (1993) 103
3. Y Myake and A Kozawa, *Rechargeable batteries in Japan*, JEC Press Inc., 1977 (USA), 177
4. K R Bullock and D Parilov, 'Advances in lead acid batteries, Proc. **84-14**, The Electrochemical Society Inc., Pennington, NJ (1984), 177
5. Hans Bode, 'Lead acid batteries', A Wiley Interscience Publications, London (1977), 157
6. Kenji et al, 'Discharge behaviour of electrodeposited PbO_2 and Pb electrodes', *J Power Sources*, 7 (1981- 82), 73
7. Nelse Hehner, 'Storage battery manufacturing manual III'.
8. A M Vineze, "Expanded Metal positive plats - production, alloy and design considerations" The Battery Man, April (1992) 26
9. Allan B Rossen, "New Developments in automotive batteries", Exide Corporation, Philadelphia, USA
10. N A Hampson and J B Lakeman, "The electrochemistry of the porous Pb electrode in - A selective Rerview" *Journal of Power Sources,* **6** (1981) 101
11. International Sympsium on Batteries, 21st - 23rd October Great Britain Ministry (1958) 170