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LEAKAGE CURRENT IN BIPOLAR MAGNESIUM-SILVER CHLORIDE BATTERY

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Magnesium-silver chloride battery was fabricated in the bipolar configuration with 3% sodium chloride as electrolyte. The effect of leakage current on the cathode material utilization efficiency in each cell compartment and the variation of capacity with number of cells in series are reported.

Keywords: Magnesium-silver chloride battery, bipolar, leakage current.

INTRODUCTION

Magnesium-silver chloride batteries are sea-water activated batteries used for a wide range of applications such as sonobuoy, lifebuoy, life raft, torpedo and other sea water detecting devices. These systems are characterised by high power and energy density, long shelf life and reliability [1]. The loss of capacity due to leakage current, hereafter called as leakage current capacity, in bipolar battery is reduced to the minimum by proper designing of the multicell battery [2,3]. In this paper, the capacity data, leakage current capacity and capacity utilization of cathode in each cell of the bipolar battery in free electrolyte flow path and partial electrolyte flow are reported.

EXPERIMENTAL

Electrode preparation

Magnesium alloy (AZ31) sheets of dimensions 6 cm x 3.5 cm x 0.5 cm were used as anodes. The cathode plate of the same dimensions was prepared by sintering silver chloride powder over a silver grid as reported earlier [4,5]. Each bipolar unit consists of magnesium plate on one side and silver chloride plate on the other side of a plastic sheet, the two electrodes being connected by a metallic wire. The plastic sheet avoids the contact of the electrolyte junction. The terminal electrodes of bipolar batteries consist of single magnesium or silver chloride electrode fixed on plastic sheet. Plastic sheets of dimensions 6 cm x 4 cm x 0.1 cm are used for the electrode fabrication for the free electrolyte flow type and partial electrolyte flow type batteries. Cathode limited bipolar batteries have been used for the present study.

Cell assembly

Free electrolyte flow type magnesium/silver chloride bipolar batteries (2 Nos.) consisting of 4 cells and 7 cells in series respectively were fabricated. The electrodes separated by plastic wire separators were encased in a plastic container having openings at the top and bottom. These openings were provided for the free flow of electrolyte when the battery is activated and for the removal of corrosion waste products formed during the discharge of the battery.

Partial electrolyte flow path battery

Magnesium/silver chloride batteries consisting of 3 cells, 5 cells and 7 cells connected in series were fabricated. The design aspects of these batteries were the same as those employed for free electrolyte flow type battery except that small holes were provided to minimise the electrolyte flow through the battery.

Leakage current capacity determination

The cell containing magnesium plate as the first electrode was designated as cell number 1 and the cells following this were numbered as 2,3 etc. The multicell batteries were discharged at a constant current of 300 mA and the cells in the discharged batteries were dismantled. The AgCl plate in each cell was removed separately and dissolved in 1:1 nitric acid. The undissolved material present was filtered and weighed. The weight of silver chloride equivalent to silver dissolved for each cell was calculated by subtracting the weight of undissolved silver chloride from the weight of

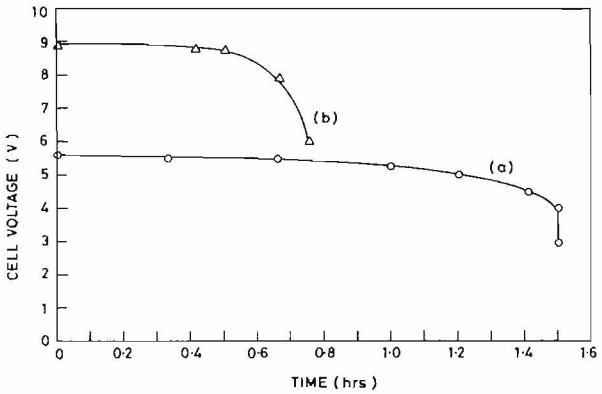

Fig. 1: Discharge curves for battery with free electrolyte flow path
a) 4 cells in series b) 7 cells in series

silver chloride used for cell fabrication. The leakage current capacity in each cell was calculated by subtracting the ampere hour capacity of the battery obtained from discharge data from the ampere hour equivalent of the reacted AgCl material (dissolved portion).

RESULTS AND DISCUSSION

Free electrolyte flow type battery

The discharge behaviour of Mg/AgCl batteries consisting of 4 cells and 7 cells in series is depicted in Fig. 1. The working voltage remained almost constant throughout the period of discharge. This figure shows that the battery capacity decreases as the number of cells in series increases. The battery consisting of 7 cells in series gave 0.75 hours of service life whereas the battery consisting of 4 cells in series gave 1.5 hours of service life at 300 mA current drain.

The variation of the leakage current capacity in different cells of the battery are presented in Fig. 2. It shows that the leakage current capacity values are lower in the cells present at the extreme side of the battery compared to the cells at the centre. The reason for the high leakage current capacity at the centre cell can be explained as follows.

For batteries with common electrolyte path a leakage current can pass through the electrolyte from the anode of one cell to the cathode of another cell. If the anode of a cell is present at a larger distance from the cathode of another cell, lesser amount of current will pass through the electrolyte and vice versa. Hence the leakage current will be greater for the cell present in the central compartment than for the cell located at the extreme position of the battery. This is evident from the experimentally obtained data.

Partial electrolyte flow type battery

The discharge behaviour of Mg/AgCl batteries consisting of 3 cells, 5 cells and 7 cells in series is shown in Fig. 3. The variation of leakage current capacity for 5 cells in series and 7 cells in series is depicted in Fig. 4. The pattern of discharge curves and leakage current capacity values obtained are same as that observed in completely opened multicell batteries. However it is evident that a lower magnitude of leakage current is observed in partially opened multicell batteries. Fig. 5 shows that as the number of cells in series increases, the ampere hour capacity of the battery decreases. This is due to the fact that the leakage current capacity associated with bipolar batteries in common electrolyte increases with

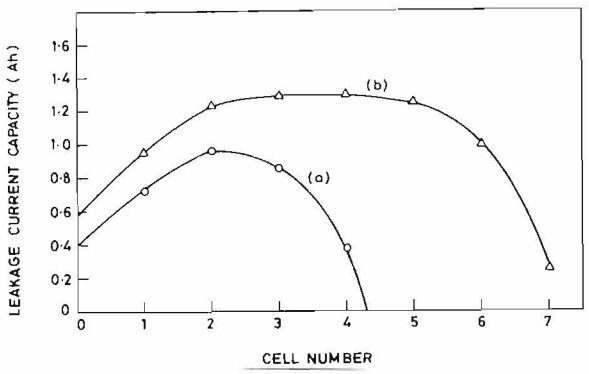

Fig. 2: Variation of leakage current capaity with cell number for batteries with free electrolyte flow path
a) 4 cells in series b) 7 cells in series

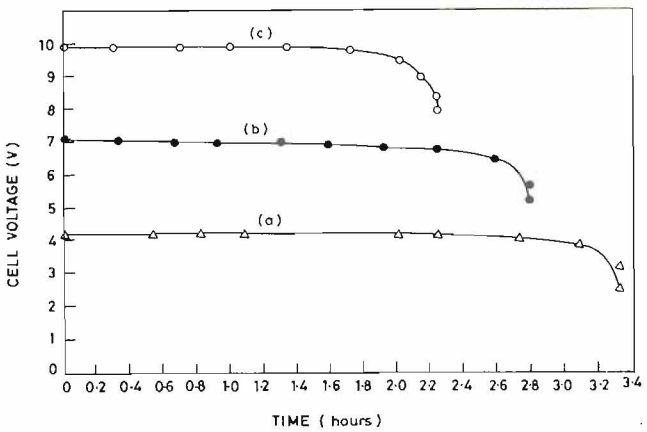

Fig. 3: Discharge curves for battery with partial electrolyte flow path
a) 3 cells in series b) 5 cells in series c) 7 cells in series

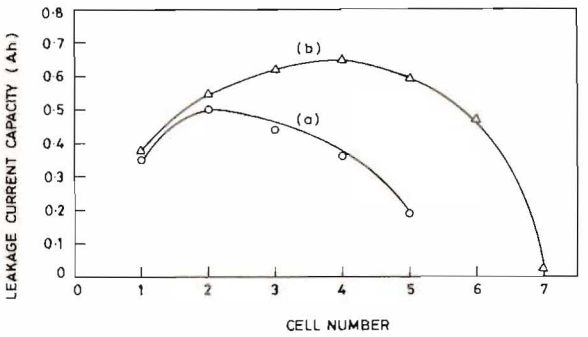

Fig. 4: Variation of leakage current capaity with cell number for batteries with partial electrolyte flow path a) 5 cells in series b) 7 cells in series

the number of cells in series resulting in loss of capacity. The straight line curve obtained for the variation of capacity with number of cells in series as depicted in Fig. 5. This can be represented by an empirical equation C + 0.087 n = 1.255, where 'C' is the capacity of the battery and 'n' is the total number of cells in series in the battery. The above equation indicates that addition of each cell results in a loss of 0.087 Ah capacity for a particular design of the battery which is reported here. The parameter 0.087 is got from the slope of the curve but may get altered for a battery of different design.

CONCLUSION

Battery capacity and leakage current capacity values were obtained for bipolar batteries in common electrolyte. The capacity of the battery decreases and leakage current capacity increases as the number of cells connected in series increases. Central compartment cells exhibited higher value of leakage current and hence lower realizable capacity compared to extreme compartments. Battery with free electrolyte flow type showed a higher leakage current compared to the battery with partial electrolyte flow type.

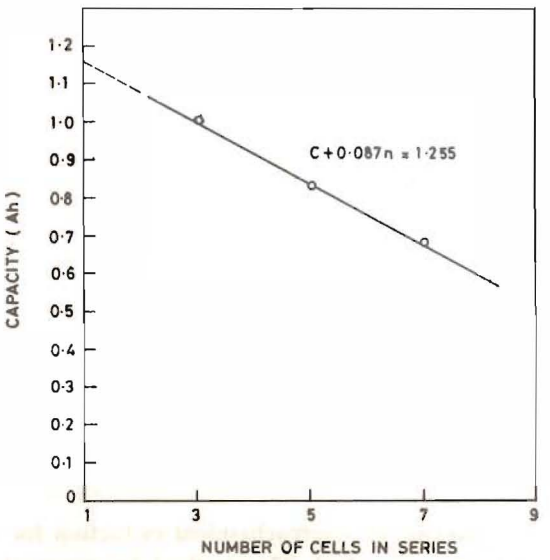

Fig. 5: Variation of capacity of the battery with number of cells connected in series

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