

**SILVER-IRON BATTERY***P PERIASAMY and C CHAKKARAVARTHY*

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[Received: 1988 January; Accepted 1988 June]

Iron-negative of porosity about 55% is made by dry powder sintering techniques. The silver powder obtained by thermal decomposition of silver oxalate is sintered to get thin porous silver plate. An alkaline silver-iron cell is assembled with three iron negatives and two silver positives. The charge-discharge data are presented in this paper indicating the limitations of cellophane paper and nylon felt as separator materials for the silver-iron rechargeable battery.

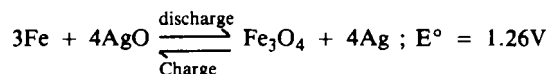
**Key words:** Silver-iron battery, silver powder, dry powder sintering, separator materials

**INTRODUCTION**

Silver-iron battery is a silver-zinc system with zinc replaced by iron. It is based on the use of porous iron as the negative electrode and silver oxide as the positive electrode with 30% KOH solution containing 15 g/l of LiOH as the electrolyte. The battery is represented as



The different reactions that take place during the charge-discharge processes are given [1] and the overall reaction is



Silver-zinc battery is a commercially developed system with a theoretical energy content of 368 Wh/kg. Its useful life is limited by the zinc electrode which after a certain number of charge-discharge cycles undergoes morphology-change known as shape change. This causes dendritic growth on the zinc electrode during charging and thereby leading to shorting of the cell. In order to minimise the dendritic growth special type of separator impermeable to zincate ion ( $ZnO_2^{--}$ ) is to be used.

The iron is an inexpensive material as compared with zinc. Its discharge product viz.  $Fe(OH)_2$  is insoluble in alkali. So the separator is not very critical when porous iron is used as the negative electrode. The replacement of the zinc electrode with the trouble-free iron actually extends the service life of the battery with the expected good performance characteristics. The silver-iron battery still retains the high energy content and power capability of the silver-zinc battery with significantly longer service life under high discharge condition.

A 140 Ah silver-iron battery weighing 1.66 kg for telecommunication purposes has been reported [2]. Preliminary work has been carried out on the silver-iron battery with the available separator materials such as cellophane and nylon felt. A silver-iron battery is assembled with sintered iron and silver plates and the results are presented in this paper.

**Fabrication of the silver positive electrode**

The active material at the positive electrode is silver oxide ( $AgO$ ) which is reduced to  $Ag_2O$  and  $Ag$  during discharge. Initially, a porous silver plate is used as the positive electrode. The active material ( $AgO$ ) is formed inside the pores during charge-discharge process. The porous silver plate is fabricated by sintering technique. Finely divided silver powder is used for this purpose.

The precipitated silver oxalate obtained by treating silver nitrate solution with ammonium oxalate is filtered, washed well and dried. The fine powder of silver oxalate is heated to about 623K when it decomposes to fine silver powder with mild explosion. The silver powder so prepared is spread uniformly on to both sides of an expanded nickel mesh. A pressure of 50-75  $kg/cm^2$  is applied to get a thin plate which is then heated to about 920K when sintering occurs. The dimension of the sintered plate is 160(H) x 75(B) x 1(T) mm with a porosity of about 55%.

**Fabrication of the iron negative electrode**

The negative electrode active material is a mixture of finely divided iron and ferrous hydroxide which are generated from the mixture of iron oxides or from porous iron substrate during the charge-discharge process. So the negative electrode initially is either porous iron plate or a plate comprising of mixture of iron oxides and iron. Three types of iron negatives are in use. They are (i) pocket or tubular type [3], (ii) pressed or rolled type [4] and (iii) sintered type [5]. In the present work sintered porous iron plate prepared by the following procedure is used to assemble the  $Ag/Fe$  battery.

Commercially available electrolytic iron powder of mean particle size 30  $\mu m$  is used for electrode fabrication. The powder is spread uniformly on to both sides of a nickel plated mild steel mesh kept in the cavity of a graphite plate. The depth and size of the cavity determine the dimension of the iron plate. Number of graphite plates having the iron powder spreadings, are stacked one over the other and heated at 1123-1173K in  $H_2$  atmosphere to get the sintered iron plates. The dimension of the sintered iron plate is 160(H) x 75(B) x 1.5(T) mm with a porosity of about 55%. The porous iron plate is suitably activated and used in assembling the  $Ag/Fe$  battery.

### Battery assembly

Three numbers of iron negatives and two numbers of silver positives are arranged alternately with a common terminal for all the negative plates and a common terminal for all the positive plates. Cellophane paper and nylon felt have been tried as the separator materials. The electrolyte is 30% KOH solution containing 15 g/l of LiOH.

### RESULTS AND DISCUSSION

With eight cellophane paper wrappings for each silver electrode the cell is charged at 5A up to 1.7V. The discharge is carried out at 5A up to 0.8V. The charge-discharge behaviour is shown in Fig.1.

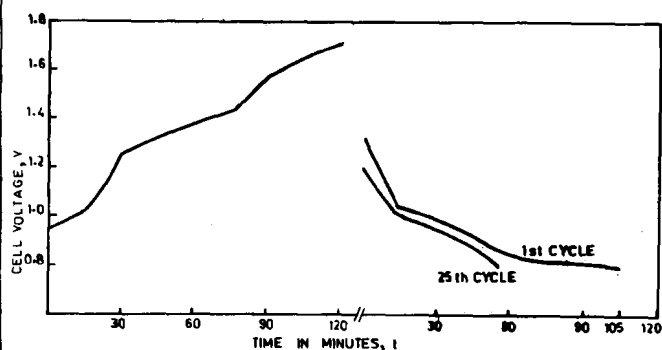


Fig. 1: Charge-discharge at 5A with cellophane separator

It could be seen from the figure that the Ah output is maximum in the first cycle and slowly decreases as the cycling is continued. The output is practically nil beyond 30th cycle. At this stage it has been noted that the cellophane wrappings have got completely disintegrated. The slow decrease in the output and the subsequent failure of the Ag/Fe cell are due to the slow physical disintegration of the separator material which leads to cell shorting.

The electrode assembly is washed thoroughly with distilled water. With nylon felt as the separator, the cell is again assembled and the cycling is continued. Fig. 2 shows the charge-discharge behaviour of the Fe/Ag cell with nylon felt as the separator.

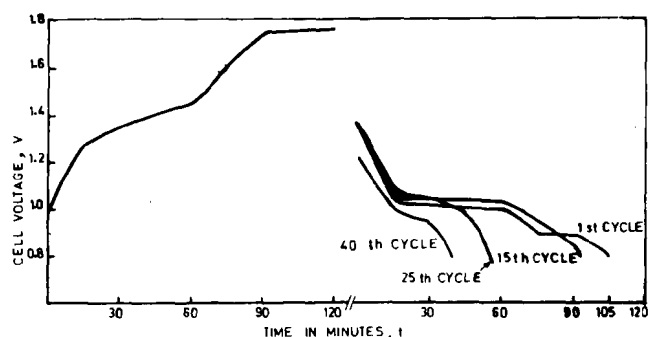


Fig.2: Charge-discharge at 5A with nylon felt separator

In this case also the output slowly decreases and the system fails to give any output beyond 45th cycle. Visual observation indicates that there is deposition of silver on the iron electrode. The separator is found to be in good condition. The deposition of silver is due to the migration of the silver ion to the negative electrode, most probably during discharge and the nylon felt is ineffective in preventing the silver ion migration. The failure in this case is due to silver deposition which causes local cell action leading to slow decrease in the output and total failure after a sizeable period of operation. Further, after a few cycles of charge-discharge, the charge retention of the battery is found to be very poor.

Realised performance characteristics of the Ag/Fe battery assembled are as follows:

Capacity	..	9Ah
Discharge voltage	..	1.3-0.8V
Energy efficiency	..	66%
Energy density	..	45 Wh/kg (at 2h rate)
Cycle life	..	75

### CONCLUSION

The performance characteristics of the assembled Ag/Fe battery are fairly good. Cellophane paper and nylon felt that have been tried in the present work are not suitable separators since the Ah output is gradually falling down as the cycling is continued. The gradual fall of the output is an indication that the disintegration of the cellophane starts gradually from the beginning and in the case of nylon felt, silver deposits on the iron electrode from the initial stage itself. Such a system is of no practical importance since charge retention will be very poor. Alkali resistant porous and silver ion impermeable separator will be the best choice to get the expected service life of the Ag/Fe battery.

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