Bulletin of Electrochemistry 6 (1) January 1990, pp 105-106

Studies on bipolar type cells for magnesium

P S Desikan, G N Kannan, K S Dandapani and S Srikantan
Central Electrochemical Research Institute, Karaikudi-623 006, INDIA

Bipolar type of cells appear to offer scope for further energy reduction for the production of magnesium metal over the hitherto most updated classes of diaphragmless monopolar modular type of cells. In order to evolve the optimum geometry for getting the best results and towards the proper design of graphite-iron bipolar plates, experiments were conducted on bench scale in bipolar systems which yielded very encouraging results in 500 A cells. Some of the results are reported.

Key words: Bipolar cell, magnesium production, energy reduction

INTRODUCTION

Even though magnesium is an abundantly available element in nature, the high energy requirement to extract the metal from its sources has limited the scope of its usage. However newer cell designs and improved technologies have brought down the specific energy requirement from 22 to 14 kWH/kg of magnesium. Modular cells, developed by CECRI have the essential features of narrow interpolar gaps and better separation of anodic and cathodic products utilising the gas lift action of chlorine. Still there seems to be much scope for further energy reduction, since the theoretical energy requirement lies around 6.5 kWH/kg of magnesium. Of all the developments taking place, the bipolar cell technology seems to be the most promising one. The principle of bipolar system is that, if an electrically conducting plate is inserted between an anode and cathode of a conventional cell, the side of the plate facing the anode becomes cathodic and the other side of the plate becomes anodic. The plate thus functions as bipolar electrode. The production of the cell is nearly doubled. If there are 'n' bipolar electrodes the production increase will be n+1 times. The advantages of bipolar type of cells are, considerable savings in energy and capital costs with high space time yields. While work in this direction is going all over the globe [1-3] CECRI has also ventured into the development of bipolar technology and some of the early work has been described elsewhere [4].

Development of stable bipolar electrode

The most important aspect of the bipolar cell lies in the fabrication of proper bipolar electrodes. Unlike aluminium bipolar cells where graphite can be used as bipolar electrode material, one has to look for a bimetallic bipolar electrode for magnesium. This is because graphite disintegrates very fast in the presence of molten magnesium.

The bimetallic electrode can be in-built wherein iron can be coated over graphite by electrodeposition or by plasma spray of iron powder. The other method to prepare such an electrode is by joining graphite and iron plates by means of iron rods.

CECRI prepared electrodeposited bipolar electrodes and tested them in a 50A electrolytic cell. It was found out that the iron coating was stable for short duration of electrolysis and hence usage of such electrodes had to be discarded. The plasma coated bipolar electrodes performed somewhat better in the sense the coating withstood for duration of 4-5 hrs in 50A capacity cells, whereas it got completely washed away by the electrolyte circulation when put into use in 500A cells for continuous operation. Moreover the current efficiencies obtained were always low (less than 40%) which enhanced the energy consumption.

Bipolar electrodes prepared by joining graphite and iron plate, were tested in electrolytic cells. The performance of these electrodes was found to be satisfactory from the viewpoints of mechanical stability and surface conditions for better deposition of magnesium. In order to improve electrolyte circulation in the electrolytic zone bipolar electrodes were assembled in such a way so that a gap of about 4 cm is formed in between graphite and iron plates. The metallic spacers in between connected the two plates and held them together.

Further improvement made in this direction was introduction of louvre arrangements in the cathode side instead of iron plate to facilitate easy ascendance of metal to the electrolyte surface.

Cell geometry and design

The cell essentially consisted of refractory lined vessel with inner dimensions of 40 × 30 × 30 cms and two bipolar electrodes apart from graphite anode and iron cathode.

TABLE-I: Features of bipolar cells performance

Ampere load (A)	... 450
Number of bipolar plates	... 2
Number of unit cells	... 3
Electrode area (cm^2)	... 450
Current density (A cm^{-2})	... 1
Voltage per unit cell (V)	... 3.5 to 3.8
Total cell voltage (V)	... 11
Inter electrode distance (cm)	... 2
Average current efficiency (%)	... 65
D. C. energy consumption (kWh/kg of mg)	... 12
Electrolyte composition % = $MgCl_2$-15, NaCl-38, KCl-35, $BaCl_2$-10, CaF_2-2	

A graphite plate vertically mounted at the rear end of the cell served as the anode and the first bipolar electrode was fixed parallel to the anode keeping an interpolar gap of 2 cm. Similarly the second bipolar plate was fixed at 2 cm away from the first bipolar electrode. The louvred cathode was also positioned 2 cm away from the second bipolar electrode. The ends of bipolar electrodes were properly confined in between the refractory bricks to minimise the bypass current. The nonelectrolytic zone in front of the cathode formed metal collection chamber.

Features of cell performance are given in Table I.

REFERENCES

1. O Sivilotti, *Light Metal Age* (August 1984) 16

2. Toship Noda, *Light Metals* (1988) 759

3. O Sivilotti, *Light Metals* (1988) 817

4. P S Desikan, G N Kannan, K S Dandapani, S Srikantan, K S Srinivasan, A Selvakesavan, SM Sukumaran, L K Srinivasan, P Subramanian, C O Augustin, T Selvin Devasahayam and N Rajagopalan, *Bull Electrochem*, 3 (1987) 125