HYDROGEN ANODE IN MOLTEN SALT MAGNESIUM PRODUCTION.

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During normal magnesium electrolysis from MgCl2 dissolved in molten salt electrolyte, magnesium metal is produced at the cathode and Cl2 gas is formed at the anode. The gas is removed from the cell and scrubbed, dried and compressed. When utilizing brines as the source for magnesium, the Cl2 becomes a byproduct for sale. In facilities where magnesium hydroxides or carbonates are the feed, the compressed chlorine is burned with H2 gas to yield hydrogen chloride gas. The latter is absorbed in water to yield hydrochloric acid, which is used in the leaching plant to dissolve the oxidic feed stock.

Due to the volume and composition of the chlorine gas produced, the capital costs of the Cl_2 handling equipment can be as much as 30 % of the total plant investment. If, alternatively, HCl gas were to be produced at the anode and collected from the cell, these capital costs would be reduced greatly through elimination of all but the scrubbing step; the latter yielding hydrochloric acid.

The use of "hydrogen" anodes for metal electrowinning has been explored in electrochemical reduction of oxygen and/or the electrochemical oxidation of hydrogen in fuel cells, metal/air batteries, gas sensors, etc (1). This has made available a variety of electrode systems and substrates for testing in the metallurgical industry (2). The substrate catalyst of choice in electrochemical oxidation of hydrogen is finely divided platinum, or alloys of the PGM group of metals. Such systems have been tested in the sulphuric acid based electrowinning of zinc (1). Cell voltage reductions of close to 2 Volts were achieved. In reference to aqueous chloride systems, however, Cl- ions poison platinum catalysts and use of such anodes requires special protection of the catalyst.

This benefit of cell voltage reduction also extends to electrowinning of magnesium metal in molten salt media due to the anodic reaction:

$$2\ Cl^- + H_2(g) \text{ ------> } 2\ HCl\ (g) + 2\ e^-$$

It can be calculated that the decomposition voltage decreases by 1.04 Volt and that the overall energy requirement decreases by 0.86V. This translates to a reduction of about 25% in energy consumption for magnesium production. With magnesium currently requiring approx. 12.5 MWh per tonne, operating costs savings of about $125 per tonne could be added to the capital costs savings.

In the late 90's, CELLMAG Inc. decided to investigate whether the predicted drop in decomposition voltage could be demonstrated on a laboratory scale, utilizing graphite anodes in contact with gaseous hydrogen. LTEE (Laboratoires des technologies electrochimique et des electrotechnologies d'Hydro-Quebec) at Shawinigan, Quebec was commissioned to do the experimental work.

Three types of tests were performed : galvanodynamic, potentiodynamic and potentiostatic tests. Results will be presented in the paper. During the potentiostatic tests, for instance, the potential was maintained at 2.3V against a Mg/Ag reference electrode. The effect of temperature on the current at this potential of 2.3 V is shown in figure 1. Sections 1,2 and 3 of the curve relate to test conditions at 680, 705 and 734 ^{0}C, respectively. Some of the results obtained are listed in the table below.

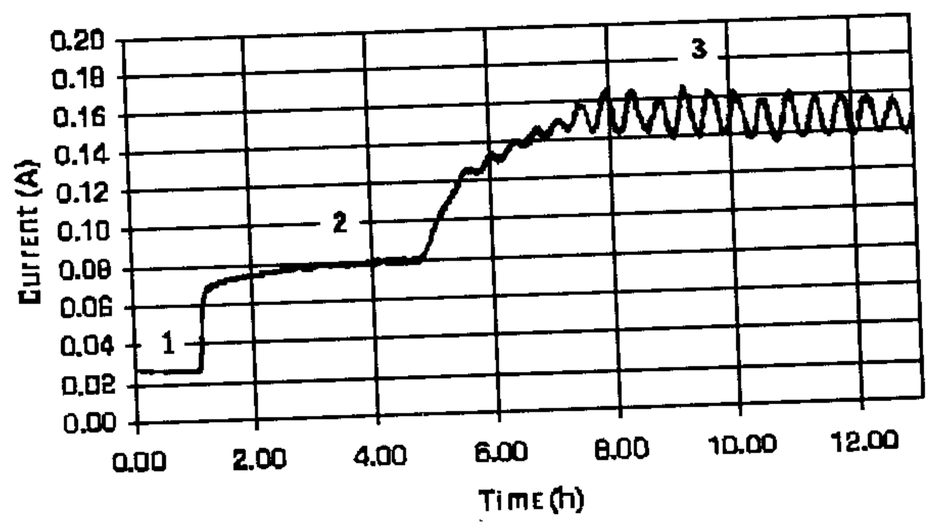

Figure 1: The effect of temperature on the current at a constant voltage of 2.3 V.

Section	Temp.	A/ m^2	Hydrogen Utilization %
1	680^{0}C	4	12
2	705^{0}C	13	38
3	734^{0}C	27	77

Ref. (1) R.J.Allen et al., "Full scale H_2 anodes for immersed tank electrowinning", JOM, March 1993, 49 – 53.

(2) L. Liao et al."Ion transport in a two membrane EW cell for the production of hydrochloric acid", Journal of Appl. Electrochemistry 25 (1995) 1009 - 1016