AEC-NASA TECH BRIEF

Iron Serves as Diffusion Barrier in Thermally Regenerative Galvanic Cell

The problem:

To provide a simple, efficient and durable hydrogen diffusion electrode for a thermally regenerative galvanic cell. The pores of porous barriers such as sintered nickel and sintered ceramics become clogged. Previous attempts to use precious metals as diffusion electrodes met with failure because of disintegration of the electrodes in the environment of the galvanic cell.

The solution:

A pure iron or iron-coated diaphragm allows hydrogen to diffuse through its interatomic spaces and resists the corrosive action of the cell environment. These diaphragms have been found to diffuse hydrogen by the same mechanism as that of the noble metals.

How it's done:

A pure iron diaphragm, between 0.1 mil and 10.0 mils in thickness, or a precious metal diaphragm coated on one side with 0.1 mil of cathode-sputtered iron, is fastened within a galvanic cell vessel to separate the fused salt electrolyte (an essentially ternary eutectic mixture of LiCl-LiI-LiH) and hydrogen gas. The electrolyte is in contact with the iron-coated side. An outer shell surrounds the galvanic cell and contains an inert gas atmosphere. The molten anode metal (lithium) is supported on a stainless steel sponge which also serves as a current collector. The iron or iron coated diaphragm acts as cathode and current collector. The electrolyte regenerator and its heat source are connected to the galvanic cell by three return lines and one outlet.

Hydrogen gas molecules in contact with the surface of the diaphragm cathode catalytically dissociate into atomic hydrogen which diffuses through the diaphragm. On reaching the electrolyte side of the diaphragm, the atomic hydrogen receives an electron from the cathode and enters the electrolyte as a hydride ion by the following reaction:

$$1/2H_2 \rightarrow H + e \rightarrow H^-$$

At the same time, atoms from the molten lithium anode enter the electrolyte, transferring an electron to the anode current collector, in accord with the following equation:

$$Li \rightarrow Li^+ - e$$

The lithium cations and the hydride anions then combine within the electrolyte to form lithium hydride:

$$Li^+ + H^- \rightarrow LiH$$

An electrical potential is thus created between the anode cap and the cathode and current flows through an external electrical circuit connecting the anode and cathode.

For regeneration, electrolyte containing the lithium hydride is pumped from the galvanic cell into the electrolyte regenerator and heated above 850°C. The LiH decomposes to form molten lithium and hydrogen gas. The lithium floats to the surface of the electrolyte within the regenerator, from which it is pumped back to the stainless steel anode sponge in the galvanic cell. The hydrogen is bled to the inlet tube in the galvanic cell behind the diffusion barrier.

Notes:

1. A thermal regenerative cell, using a pure rolled iron barrier 10 mils thick, an LiCl–KCl eutectic electrolyte, and the previously mentioned anode material yielded a 0.75-volt initial potential and a steady state potential of 0.6009 volt over a period of 216 operating hours. The current density was 28 amperes per square foot of anode area. The cell vessel was 4½ inches high and 4½ inches in diameter. The electrolyte was maintained at 400°C, and the regenerator was operated near 1000°C.

(continued overleaf)

2. The cell hydrogen supply should be supplemented by an external hydrogen source to compensate for the small hydrogen losses during operation.
3. The cell should contain an inert atmosphere above the electrolyte.
4. Additional details are contained in: Patent #3,119,723, which is available from the U.S. Patent Office; $0.50 each.
5. Inquiries concerning this innovation may be directed to:

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Reference: B67-10189

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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