

SODIUM-SULFUR BATTERY DEVELOPMENT

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The objective of this program is to develop rechargeable Na-S cells and batteries using the walls of glass hollow fibers as the electrolyte. Liquid Na is contained in the lumen of the fiber and sulfur-sulfide melt surrounds the outside. This cell will give high energy and power densities -- over 200 W h/kg and 180 W/kg, respectively, for the bare cell. Overall power efficiencies will be about 90%. Uses are aimed at load leveling for utilities and electrochemical plants, photovoltaic energy storage, and for vehicle propulsion.

The ultimate goals of this developmental effort include building batteries for the above purposes with lifetimes of over 7 years and costing less than \$35 per kW h (1979 dollars).

Hundreds of 6 A h cells have been assembled and operated under various conditions. Several of the cells ran as long as one year on continuous cycling, giving up to 518 cycles at over 80% of capacity. Several larger 20 and 40 A h cells were constructed, but lifetimes were short -- approximately two weeks. Failures are mostly due to fiber breakage in the vicinity of the tubesheet. In "well-behaved" cells, cell resistance stays constant through the life of the cell and cell capacity either stays constant or increases slightly. Fifteen cells ran over 200 deep charge-discharge cycles, eight over 300 cycles, and three over 400 cycles.

Long life cells are failing due to distortion of the tubesheet. New tubesheet glass compositions and structures have been developed that should cure this problem as well as reducing the brittle fracture of the glass capillaries at the fiber-tubesheet junction.

The aluminum cathode foils are now coated with 300 Å of molybdenum by sputtering rather than by Mo evaporation. This gives cathodes which do not change resistance during the life of the cell.

A cell testing system to charge-discharge up to 40 cells automatically has been built. The system continuously monitors the cells, recording and printing out pertinent electrochemical results in chart or graph form.

A conservative cost estimate, made using A. D. Little guidelines, suggests a maximum cost of \$32/kW h for the bare metal-cased cell. This is based on a 400 A h, 800 W h cell (1979 dollars).

The major problems include: (1) discovering why all "identical" cells do not have identical resistances and capacities; (2) scaling up the cell to long-lived 40 and 400 A h capacities; (3) making "safe" cells such that the metal case is not breached in the worst conceivable accident; (4) replacing the 0.120 in. thick stainless steel case with a thin 0.015 in. wall case; (5) perfecting the new tubesheet glass structures; (6) designing and assembling batteries from the individual cells.

The technical objectives for the next year include: (1) enhancing the lifetime of the 6 A h cell; (2) making an increased number capable of over 600 deep charge-discharge cycles with a round trip efficiency of 90% at the 8 h rate; (3) making 40 A h cells capable of over 150 deep charge-discharge cycles; (4) conducting research toward the development of the 400 A h cell. In addition, continuing development will be done toward scaling up the processes by which the parts of the cell, *e.g.*, fibers, are made. Studies on the design of batteries utilizing these cells are being started.

Recent publications

- 1 C. Levine, The hollow fiber Na-S battery for propulsion — promise, problems, prognosis, *Electrochem. Soc. Meeting, Pittsburg, PA, October 15 - 20, 1978*.
- 2 C. Levine, Development of a hollow glass fiber Na-S cell, *Int. Soc. Electrochemistry, Budapest, September 1, 1978*.
- 3 T. Revak and P. Filice, Computer design of Dow hollow fiber Na-S battery cell, *Dow Rep. GP-1879, January 12, 1978*.
- 4 W. E. Brown, Sodium-sulfur battery: Hewlett-Packard Data Acquisition System, *Dow Rep. GP-1935, July 20, 1978*.
- 5 F. Tsang, Current status of the hollow fiber sodium-sulfur cell, *Power Sources Conf., June 13, 1978*.
- 6 M. Li Wu, Development and production of better tubesheets for hollow fiber Na-S cells, *Dow Rep. GP-2054, May 10, 1979*.
- 7 C. Levine, Summary status report on Dow Na-S battery, *Dow Internal Rep. GP-2075, July 9, 1979*.
- 8 J. Anand, Dow sodium-sulfur battery for load levelling, *14th Intersoc. Energy Conversion Eng. Conf., Boston, MA, August 5 - 10, 1979*.