ZINC/BROMINE BATTERY DEVELOPMENT — PHASE II

Exxon Research and Engineering Company, Box 8, Linden, NJ 07036 (U.S.A.)

The objective of this project was to develop the core technology for a bipolar zinc/bromine flow battery that could eventually be adapted to various advanced battery applications. System scale-up to 20 kW h for 50 cycles was the demonstration target.

Exxon Research and Engineering has been developing bipolar zinc/bromine flow battery technology for several years on its own funds. This Phase II program was cost-shared with DOE and continues an earlier Phase I program. During Phase II, the system was scaled up to an 80-V, 20-kW h design and cycled to 70 plus cycles using 600-cm^2 electrodes. Life cycling on automatic parametric testing stations (500-W h, eight-cell bipolar stacks) extended demonstrated life from 150 deep cycles to over 400 deep cycles and 1400 shallow cycles. A simplified two-piece (co-extruded electrode and integral separator/flow frame) cell construction was demonstrated, which is capable of low cost mass manufacturing using existing commercial plastic fabrication techniques. High conductivity supported electrolytes that both improved efficiency for bulk energy storage and produce more power on electric vehicle cycle (J227aD) simulations were demonstrated. Finally, the next generation of components, 1200-cm^2 electrodes of the two-piece construction, were designed to use the high conductivity electrolytes and the recent concepts in 'tunnel shunt current protection'.

All Phase II tasks are complete. Future work will continue under Phase III.

ZINC/BROMINE BATTERY DEVELOPMENT — PHASE III

Exxon Research and Engineering Company, Box 8, Linden, NJ 07036 (U.S.A.)

The objective of this project is to develop the core technology for a bipolar zinc/bromine flow battery that could eventually be adapted to various advanced battery applications. A 20-kW h battery, designed for stationary domestic photovoltaic applications, is a deliverable.

This cost-shared contract will culminate previous development work in Phases I and II by optimizing the design concepts into a final 20-kW h deliverable demonstrator battery. The first 20-kW h battery from Phase II has been extended to over 135 cycles. Parametric studies (500-kW h, eight-

cell bipolar stacks) have demonstrated over 500 randomly discharged cycles, with up to 50 continuous random cycles between stripping. Mechanisms of cell failure were associated with removable residues in the microporous separators. Perhaps this insight will extend life studies into the range of 500 to 1000 cycles.

The first 1200-cm^2 electrodes, designed in Phase II with the simplified two-piece design, were fabricated and assembled in 1-kW h, eight-cell bipolar stacks. These units show improved performance, less internal resistance, and sharper cut-off voltages than the equivalent 600-cm^2 electrodes. A 78-cell bipolar stack is under construction. Progress on flow battery auxiliaries has demonstrated high pump efficiencies (greater than 30 percent) exceeding the design requirements for the final Phase III 20-kW h deliverable. A microprocessor controller, similar to that required for the 20-kW h deliverable, has been built and demonstrated and automatically controls all battery monitoring and control functions.

In early 1983, a 10-kW h, 78-cell, 120-V bipolar stack and battery will be demonstrated. This test represents both a critical test of 'tunnel' shunt current protection and a demonstration of the basic building block to be used for future optimized electric vehicle and bulk energy storage batteries. Next, a 20-kW h, two-stack battery will be built in preparation for the final 20-kW h deliverable in 1984. During 1983, this 20-kW h battery will be used to characterize 20-kW h battery performance and to test and size various auxiliaries such as pumps, protective electrodes, waste heat removal, and the microprocessor controller.

Auxiliary development will continue to investigate improvements in state of charge monitors, pumps, the microprocessor controller, etc. Anticipated part preparation and component manufacturing bottlenecks will be investigated. Parametric testing (500 to 1000 W h) will attempt to extend life into the 500 to 1000 cycle range, extend high and low temperature operating limits, and characterize operational aspects of the zinc/bromine system. A computer program will be expanded to model system operation and correlate testing data.

Recent publications

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4 R. Bellows, K. Newby and C. Elspass, Potentiometric oxidation of carbon plastic electrodes, *Electrochemical Society Meeting, Denver, CO, October 1981.*

5 H. Einstein, R. Bellows, P. Grimes *et al.*, Design and cost analysis of a 20 kW h bipolar zinc–bromine battery, *EVC Symposium VI, Baltimore, MD, October 1981.*

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8 P. Grimes, Recent progress on Exxon's circulating zinc–bromine battery system, *Fourth U.S. Department of Energy Battery and Electrochemical Contractors' Conference, Washington, DC, June 2, 1981.*
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15 P. A. Malachesky, H. Einstein, R. Bellows *et al.*, Bipolar Zn–Br_2 batteries for electric and hybrid vehicles, *Electrochemical Society Meeting, Minneapolis, MN, May 1981.*
16 H. C. Tsien, Co-extruded bipolar electrode for zinc–bromine battery-conductive-plastic speeds development of advanced storage battery, *Plastics Engineering, 21* (August 1981).
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NASA REDOX STORAGE SYSTEM TECHNOLOGY PROJECT

Lewis Research Center, National Aeronautics and Space Administration, Cleveland, OH 44135 (U.S.A.)

The objective is to develop and validate the iron–chromium redox technology to establish the basis for system design and evaluation. During 1982 work was undertaken to:

- Develop an understanding of the solution chemistry of the chromium chloride reactant and its relationship to cell performance characteristics;