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ADVANCED HIGH-TEMPERATURE BATTERIES

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Work has been under way for about two decades on high-temperature batteries having lithium or sodium negative electrodes. These efforts have met with some success but the original promise of very high specific energy and power has not yet been achieved for practical battery systems. This paper discusses some recent new approaches to achieving high performance for lithium/FeS_2 cells and sodium/metal chloride cells.

The main problems for the development of successful LiAl/FeS_2 cells have been (1) the instability of the FeS_2 electrode, which has resulted in rapidly declining capacity, (2) the lack of an internal mechanism for accommodating overcharge of a cell, thus requiring the use of external charge control on each individual cell, and (3) the lack of a suitable current collector for the positive electrode other than expensive molybdenum sheet material. Much progress has been made at ANL in solving the first two problems. Reduction of the operating temperatures to 400°C by a change in electrolyte composition has increased the expected life to 1000 cycles. Also, a lithium shuttle mechanism has been demonstrated for selected electrode compositions that permits sufficient overcharge tolerance to adjust for the normally expected cell-to-cell deviation in coulombic efficiency. Recent new work on bipolar cells indicates that the third problem might be solved for a bipolar battery by the use of a coating on the positive side of the cell dividers, which could result in a low-cost means of transmitting current from the positive electrode. Also, bipolar cells are very efficient in the use of structural material and other non-active materials in the cell. Calculations show that a specific energy of 200 Wh/kg and 300 W/kg could be achieved with this design for moderately thick electrodes. Tests of very thin electrodes of this type have demonstrated very high power for periods of less than a second; batteries having such electrodes may be appropriate for pulse-power applications.

Sodium/sulfur batteries and sodium/metal chloride batteries have demonstrated good reliability and long cycle life. For applications where very high power is desired, new electrolyte configurations would be required. Design work has been carried out at ANL for the sodium/metal chloride battery that demonstrates the feasibility of achieving high specific energy (190 Wh/kg) and high power (>400 W/kg at two-thirds open circuit voltage) for large (>200 Ah) battery cells having thin-walled high-surface area electrolytes. These electrolytes can be configured as small tubes (5 to 8 mm dia) joined together by a ceramic or metallic header or as a flat-plate compartmented electrolyte structure. Such structures were studied at ANL for the sodium/metal chloride system because of the limited power capabilities of that system at its operating temperature of 250°C or lower. The conclusion reached in that study, that high power can be achieved for large cells of this design, would seem to be valid for sodium/sulfur cells as well.

Future efforts to improve the performance and reliability of both lithium and sodium anode high-temperature batteries are expected to result in battery systems that meet the goals that were originally set when the development efforts were first initiated: specific energy of about 220 Wh/kg and specific power of 300 to 400 W/kg.