- The contract efforts for membrane and electrode development will be completed.

Recent publications

1 Advances in membrane technology for the NASA redox energy storage system, *DOE/NASA/12726-12, NASA TM-82701*, 1980.
2 Anion permselective membrane, Ionics Inc., *DOE/NASA/0137-1, NASA CR-165223*, 1980.
3 Anion permselective membrane, *DOE/NASA/0204-1, NASA CR-167872.*
4 The chemical and electrochemical behavior of Cr(II)/Cr(III) half-cell in the NASA redox energy storage system, *DOE/NASA/12726-17, NASA TM-82913.*
5 Cost projections for redox energy storage systems, United Technologies Corp., *DOE/NASA/0126-1, NASA CR-265260*, 1980.
6 Design and assembly considerations for redox cells and stacks, *DOE/NASA/12726-10, NASA TM-82672*, 1981.
7 Improvement and scale-up of the NASA redox storage system, *DOE/NASA/12726-6, NASA TM-8-1672*, 1980.
8 NASA preprototype redox storage system for a photovoltaic stand-alone application, *DOE/NASA/12726-8, NASA TM-82607*, 1981.
9 Optimization and fabrication of porous carbon electrodes for iron/chromium redox flow cells, Giner Inc., *NASA CR-167921, DOE/NASA/0198-1.*
10 Performance mapping studies in redox flow cells, *DOE/NASA/12726-13, NASA TM-82707*, 1981.
11 Performance of advanced chromium electrodes for the NASA redox energy storage system, *DOE/NASA/12726-15, NASA TM-82724*, November 1981.
12 Preparation and characterization of electrodes for the NASA redox storage system, *DOE/NASA/12726-13, NASA TM-82702*, 1980.
13 Pumping power considerations in the designs of NASA redox flow cells, *DOE/NASA/12726-7, NASA TM-82598*, 1981.
14 A redox system design for solar storage applications, *DOE/NASA/12726-24, NASA TM-82720*, 1981.
15 Requirements for optimization of electrodes and electrolytes for the iron/chromium redox flow cell, *DOE/NASA/0097 80/1, NASA CR-165218*, 1981.
16 Shunt current, pumping power, cell performance trade offs in NASA redox cell stacks, *DOE/NASA/12726-17, NASA TM-82686*, 1981.

RESEARCH AND DEVELOPMENT OF A RECHARGEABLE ALKALINE ZINC/FERRICYANIDE HYBRID REDOX BATTERY

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Lockheed's research efforts over this reporting period were focused on assessing the technical feasibility of the alkaline zinc/ferricyanide rechargeable battery for utility load leveling and solar-photovoltaic applications.

This battery meets the requirements for these applications with cell voltages of 1.90 V on charge and 1.62 V on discharge (35 mA/cm^2, 40 °C), with a peak power density of 4.5 kW/m^2. A mean energy efficiency of 84 percent was obtained after 950 4-h cycles using a sintered nickel porous-flow-through positive electrode, a Nafion N-114 separator, and a cadmium-plated iron substrate for zinc deposition. The goal of replacement of sintered nickel by graphite felt has been successfully met with 670 4-h cycles (70 mA h/cm^2 capacity) currently logged, at an energy efficiency of 74 percent. The reduced efficiency is totally due to the use of a separator with higher resistance (Nafion N-125) in current testing, because the N-114 separator is no longer available. Zinc half-cell storage capacity has been demonstrated at 175 cycles for a capacity of 300 mA h/cm^2 and at 260 cycles for a level of 200 mA h/cm^2 with essentially the same values of coulombic efficiency. Similarly, a full-cell test is currently in progress, with 150 cycles logged at capacities between 200 and 300 mA h/cm^2.

Recent work has emphasized the assessment of criteria for scale-up to 1000-cm^2 single cells, evaluation of the solid reactant storage parameters, and definition of the random cycle switching characteristics crucial to solar photovoltaic applications. In addition, studies have focused on material compatibility with alkaline ferricyanide, separator screening, and development of a conceptual engineering design for the zinc/ferricyanide battery system.

The critical technical areas to be addressed during 1982 - 1983 include membrane technology development, critical issues in crystallizer evaluation, continued scale-up and cycle life measurements of cell components, and development of suitable electrode technology to convert the system from monopolar to bipolar configuration.

Recent publications

1 G. B. Adams, R. P. Hollandsworth and E. L. Littauer, Rechargeable alkaline zinc/ferricyanide hybrid redox battery, *Proc. 16th Intsoc. Energy Conversion and Eng., Am. Soc. Mech. Eng. Conf., Paper #819383*, 1981, pp. 812 - 816.

FOULING AND CONDUCTANCE OF ANIONIC PERMSELECTIVE MEMBRANES

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The objectives are to examine the fouling mechanism and to model the membrane's conductance in order to understand how the membrane's structure affects its performance. This understanding will aid in the modification of existing membranes and the synthesis of new membranes.