2 H. N. Seiger, A critique of the zinc electrode in alkaline secondary batteries, *154th Meeting Electrochem. Soc., Pittsburgh, 1978.*

HIGH CYCLE LIFE, HIGH RATE NICKEL–ZINC BATTERIES

Power Sources Division, US Army Electronics Technology and Devices Laboratory (ERADCOM), Fort Monmouth, NJ 07703 (U.S.A.)

General purpose/goals

This project is being jointly funded by the Departments of Energy, Navy and the Army. The objectives of the project being conducted by ERADCOM are: (a) to develop and evaluate new separator systems for nickel/zinc cells which are resistant to zinc penetration shorts, (b) selection of successful mercury substitutes in the zinc anode which reduce the rate of shape change (corrosion and slumping) on cycling, and (c) the development of a semi-sealed nickel–zinc battery which operates on the oxygen cycle and is maintenance-free by means of pressure cutoff control on charge.

It is projected that the above concept will provide for a cost effective nickel–zinc battery which will exceed 300 deep cycles with a capacity retention of over 80% and have an energy density over 35 W h/lb, based on rated capacity.

(1) Nickel–zinc cells with separator wraps consisting of two 0.001 in. nickel-coated, microporous polypropylene layers sandwiched between two 0.001 in. layers of uncoated membranes were resistant to shorting during 53 deep C/5 rate cycles with overcharges of 250% per cycle. These cells delivered 90% of theoretical capacity (nickel limiting) during the 53 cycles. Cells with uncoated separator wraps shorted intermittently during the 53 cycles and delivered 66% of theoretical at cycle 53.

(2) Capacity retentions of 85 - 88% of initial values were obtained after 110 cycles at 80% depth of discharge (at the C/5 rates of charge and discharge) with 5.0 A h nickel–zinc cells having the following features:

(a) pressure cutoff on charge at 8 psig;

(b) c.p. charging at 1.89 V/cell;

(c) an anode composition of 95% ZnO, 2% CdO, 1% PbO, and 2% Teflon;

(d) electrolyte starved, using 34% KOH + 1% LiOH;

(e) a separator system consisting of thin cellulosic layers sandwiched between two protective layers of 0.001 in. microporous polypropylene;

(f) a safety venting at 10 psig ± 0.5 psig.

Work is presently being directed towards (a) immobilizing the nickel layer of the separator system within the cationic region, which is sandwiched between two non-degradable layers of microporous polypropylene (to prevent contamination of the zinc anodes), (b) evaluating mercury substitutes

with high hydrogen over-potentials (Pb, Tl, Cd and In) in concentration ranges of 0.5 - 5% so as further to improve the gas suppression and stability of the zinc anode on cycling, and (c) testing 4 cell batteries with a pressure switch attached to one cell, the pilot cell (at present a 3 cell unit with one pilot cell has attained over 200 cycles with excellent cell balance).

Major technical problems

The primary failure mode of the nickel–zinc battery is shorting by zinc penetration. The second major failure of this battery is shape change (erosion) of the zinc anodes. The first failure mode is catastrophic and occasionally premature, while the second mode is slow but cumulative. The major thrust against the shorting problem is by means of the nickelized separator system. Preventative methods include preventing overcharge by means of pressure cutoff controls, designing the cells as sealed units which operate on the oxygen cycle, and by employing constant potential and/or pulsed charging modes. The shape change problem is being approached by (a) additives in the zinc anode which suppress gassing and behave as corrosion inhibitors and expanders, (b) agitative systems that prevent zinc oxide precipitation and severe electro-osmotic pumping effects, and (c) developing a stable, high, ionic conducting cationic gelled media for the zinc anode.

The areas requiring considerable work are the stable nickelized separator — this work is being primarily carried out by Celanese Plastics Company — and the gelled media for the zinc anodes. It is estimated that these two tasks will reach a successful conclusion by the end of 1980, after which the follow-up will be mainly with battery design, construction and testing.

Recent publications

1 O. C. Wagner, High cycle life, high rate nickel–zinc batteries, *Report No. 1, US Army Electronics Technology and Devices Laboratory (ERADCOM), March 1978, Report No. PSD-1C.*

2 O. C. Wagner, High cycle life, high rate nickel–zinc batteries, *Report No. 2, US Army Electronics Technology and Devices Laboratory (ERADCOM), March 1979, Report No. PSD-2C.*

3 O. C. Wagner, High cycle life, high rate nickel–zinc batteries, August 1979, *Extended Abstract in the Extended Abstracts of the Battery Division of the Electrochemical Society, Inc., for the Fall (Oct 79) Los Angeles Meeting.*