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A NEW CONCEPT FOR HIGH-CYLCLE-LIFE LEO: RECHARGEABLE MnO_2-HYDROGEN

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The nickel-hydrogen secondary battery system is now the one of choice for use in GEO satellites. It offers superior energy density to that of nickel-cadmium, with a lifetime that is at least comparable in terms of both cycle life and overall operating life. While the number of deep cycles required for GEO use is small, LEO satellites with long lifetimes (5 to 10 years) will require secondary battery systems allowing 30,000 to 60,000 useful cycles which are characterized by an approximately 2C charge rate and C average discharge rate. These requirements are extremely difficult to attain with any existing battery system, though they can be attained with individual half-cells, especially those with non-consumable catalytic electrodes producing and consuming gaseous products.

The best example of such a system is the rechargeable bifunctional hydrogen electrode familiar from the nickel-hydrogen cell. This uses a platinum-based catalyst, which is immune to corrosion under all conditions. However, corrosion of the sintered nickel support of the nickel positive, combined with lattice contraction and expansion of active material during charge, eventually result in breakdown. This is a function of initial KOH concentration and range of discharge, As a result, the nickel-hydrogen system must be derated for LEO use, so that it offers only about 20 Wh/kg, instead of about 60 Wh/kg for a system designed for 100% depth-of-discharge.

Recent work has shown that birnessite MnO_2 doped with bismuth oxide can be cycled at very high rates (6C) over a very large number of cycles (thousands) at depths-of-discharge in the 85% - 90% range, based on two electrons, which discharge at the same potential in a flat plateau. The potential is about 0.7 V vs. hydrogen, with a cut-off at 0.6 V. At first sight, this low voltage would seem to be a disadvantage, since the theoretical energy density will be low. However, it permits the use of lightweight materials that are immune from corrosion at the positive. The high utilization and low equivalent weight of the active material, together with the use of teflon-bonded graphite for current collection, result in very light positives, especially when these are compared with those in a derated nickel-hydrogen system. In addition, the weight of the pressure vessel falls somewhat, since the dead volume is lower. Calculations show that a total system will have 2.5 times the Ah capacity of a derated nickel-hydrogen LEO battery, so that the energy density, based on 1.2 V for nickel-hydrogen and 0.7 V for MnO_2-hydrogen, will be 45% higher for comparable cycling performance.

Present work on this system concept, which involves microcalorimeter studies of self-discharge as well as cycling performance, will be described.