Journal of Power Sources, 11 (1984) 1 - 2

THE LEAD–ACID BATTERY — A PERSONAL VIEW

R. G. ACTON

Oldham Batteries Ltd., Denton, Manchester (U.K.)

Eighty years after the publication of E. J. Wade's classic book on Secondary Batteries the lead–acid system continues to puzzle, to fascinate and sometimes to irritate the enquiring technologist whilst at the same time satisfying a massive worldwide demand for a cheap and reliable energy storage and conversion system. Vast improvements have been made during those eighty years and we have now reached approximately 25% of the energy storage capability of the theoretically ideal lead oxide–lead–sulphuric acid system. Figure 1 charts the improvement in specific energy and energy density of long life traction batteries achieved during the last thirty years. A modest achievement, one might think, but it has required considerable skill in a wide range of disciplines to achieve it at an acceptable product cost. The most productive areas of research and development have been electrochemistry and materials science. The latter field has produced great advances in the metallurgy of lead alloys and hence the production of reliable lightweight current collectors, much deeper understanding of the structure and properties of the porous active materials, particularly lead dioxide, and great improvements in the production of porous membranes for use as separators between the positive and negative electrodes. Materials science has also contributed substantially to the reduction of the mass and cost of packaging the electrodes and electrolyte and, indirectly, to the development of improved electrode and battery production systems.

How will further improvements in the lead–acid system arise? Which areas of research are most likely to yield crucial discoveries or shed new light on old problems?

The mechanism by which Planté produced his electrodes, namely the anodic corrosion of lead in sulphuric acid, not only makes possible the production of a lead–acid cell but also guarantees its ultimate destruction. A complete description of the grid corrosion process, and in particular unambiguous identification of the rate controlling process, is not yet available to the lead–acid cell technologist. If it were, and if this further understanding showed how the process could be slowed down, there could be a further major improvement in the durability and specific energy of the system. As we are probably dealing with transport of oxygen through solid lead oxides it seems most likely that the techniques of solid state science will yield useful information on this problem. The relationship, if any, between oxygen transport and electronic conductivity, seems to be a topic well worth pursuing, particularly as grid corrosion is a potential dependent process.

0378-7753/84/$3.00

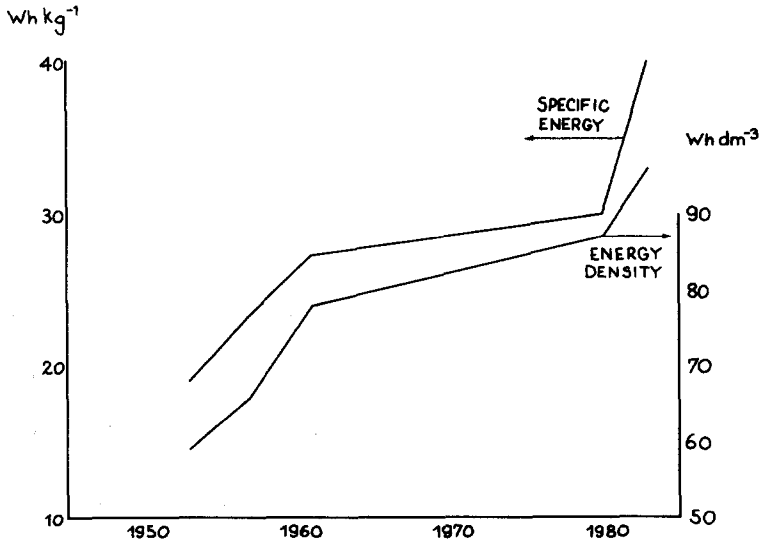

Fig. 1. Improvements in specific energy and energy density of long life traction batteries during the last thirty years.

Considerable use has been made of a variety of microscope techniques for studying the morphology of lead dioxide and to a limited extent lead electrodes. A somewhat neglected technique in this general field has been transmission optical microscopy. This technique has the advantage of producing coloured images and, by absorption measurements, can assist in establishing the electron band structure of the material. There is also the possibility of direct observation of the discharge–charge process through the walls of a specially constructed cell. Direct observation of the grid corrosion process should also be possible by this method.

A solution to the 'antimony-free' problem is long overdue. The rapid loss of capacity of positive plates made with antimony-free grids which sometimes, but not always, occurs when such cells are cycled has not yet been satisfactorily explained.

Having lived for many years in houses with no mains electricity supply in which lighting and other electrical services were supplied by antimony-free Planté batteries recharged daily from a DC generator, the present author is continually puzzled by the existence of the antimony-free effect. However, his observations on the morphology of lead dioxide in antimony-containing and antimony-free cells indicates that it is a very real but probably soluble problem. The techniques of microscopy, X-ray diffraction, and neutron diffraction and scattering are gradually yielding new pieces for this fascinating jig-saw puzzle. When it is complete the lead–acid technologist will be armed with additional weapons in his efforts to improve the durability, resistance to abuse and maintenance requirements of his product.