DEVELOPMENT OF COMMERCIAL PROTOTYPE ADVANCED VALVE-REGULATED LEAD-ACID BATTERIES FOR ELECTRIC VEHICLES

Contractor
Trojan Battery

Cosponsors
Trojan Battery Company

Project Officer
Lisa Mirisola

Background

The advanced lead acid battery proposed for use in electric and hybrid electric vehicles is a totally maintenance free design using the valve regulated lead acid battery (VRLA) technology. The strong economic advantage in using advanced lead acid batteries in these applications is that these batteries can be manufactured using existing commercial battery manufacturing equipment , without the need for substantial capital investment. A full recycling infrastructure is also in place for lead acid batteries.

For EV and hybrid EV applications, the challenges are in maximizing lead acid battery performance to increase the specific energy i.e. vehicle range. In an earlier ALABC co-funded program, Trojan Battery Company and ENSCI Inc. had demonstrated the unique use of additives to improve specific energy, capacity and cycle life of a 2V VRLA cell. The increase in specific energy and overall capacity was achieved through the use of additives incorporated in the active material of the battery plates.

Project Objective

The objective of this project was to build and demonstrate performance in 12V battery modules using the additives evaluated earlier in 2V cells. The planned approach was to build commercial prototype 12V battery modules using plates incorporating the different additives and demonstrate performance of these modules individually and as part of full scale electric vehicle battery packs.

Technology Description

Separate additives were proposed for evaluation in the positive and negative plates. In a VRLA battery, improvement in porosity of the positive active material allows for increased acid availability and enhanced positive active material utilization. The porosity additives evaluated in the positive paste were the ES-60 (inorganic based, primarily silica) and the ES-100 (organic, porous polypropylene particles, less than 125 microns).

In VRLA batteries, the negative plates can be effected by metallic impurities, resulting inperformance degradation (i.e. increased self discharge rate, hydrogen evolution, poor oxygen recombination and increased water loss). The use of ES-A4 metal control additive (which irreversibly bind trace metal contaminants like antimony, and iron) had been found to be beneficial in earlier studies and this was incorporated into the evaluation test matrix. The effect of this additive in negative plates was evaluated both by itself and also in conjunction with the ES-60 porosity additive.

Status

<u>Test Plan</u>
The test plan called for the assembly of a full matrix of batteries with plates incorporating multiple additive formulations with initial testing at the 12V module level and continuing through battery pack assembly and testing along with post mortem analysis. Utilizing the services of the National

Renewable Energy Laboratory, the plan called for analyzing battery modules and battery packs for thermal management and performance during cycling tests simulating electric vehicle operation.

Plates containing different additive combinations would be thoroughly characterized using X-Ray diffraction analysis, scanning electron microscopy, surface area and porosity measurement techniques. These plates would be assembled into 12V battery modules and fully characterized at the module level. This series of tests would include initial capacity and constant power testing, along with life tests leading into USABC electric vehicle duty cycle simulation testing and the determination of peak power and specific energy at the module level under these test regimes.

Based on initial module level tests with the performance enhancing additives, 12V battery configurations demonstrating a minimum 15% improvement over base line designs would be identified. These modules would be incorporated in full size electric vehicle packs for characterization of performance in a large battery pack configuration on static tests. These enhanced performance battery packs would then be demonstrated in real life electric vehicle application.

Battery Build

A total of approximately 24,000 positive and negative grids were made using high purity proprietary Trojan lead tin calcium alloys. The grids were controlled to uniform thickness to ensure uniform compression in the VRLA assembled battery. The positive and negative grids from these controlled batches were used for pasting plates containing the different porosity enhancing additives. Following curing and drying, these plates were processed through our dry charge process and plate samples were again analyzed to verify that the lead dioxide and free lead levels met Trojan specifications and to measure the porosity levels in the formed active material. Measurable porosity difference was found between formed plates with the additives as compared to the control plates.

Using these plates, a total of one hundred and eleven batteries were built, 56 batteries in the VRLA gel configuration and 55 batteries in the VRLA AGM configuration.

Results

Based on 12V battery level testing, use of the porosity additive in positive plates yielded an improvement in positive paste utilization of 10% in both the gel and AGM batteries. With a combination of the porosity additive ES-100 in the positive and the metal control additive ESA-4 in the negative plates, active material utilization was improved 14% in gel batteries and up to 20% in AGM batteries, in early cycling.

Batteries were shipped to NREL for thermal characterization. However, since the batteries had not been cycled to peak capacity, testing was discontinued by NREL after the first 12 cycles, due to equipment limitations. Testing at Trojan Battery Company was discontinued from March 2002 due to changes in personnel and business strategy realignment.

Conclusions

Although lead acid batteries are still lower cost than other battery chemistries, decreasing cost, longer life and increasing reliability of other battery chemistries have lead to a shift by automakers to NiMH and increasingly LiIon chemistries in light duty automotive products. Lead acid technology still dominates products where weight and packaging are minor issues and low initial cost is the driving factor such as in electric forklifts where weight provides a counterbalance benefit for heavy lifting.

Project Costs

The total project cost was $197,590 as shown:

Trojan Battery Company	$109,931
South Coast AQMD	87,659