Published on **Hawaii Natural Energy Institute** (http://www.hnei.hawaii.edu)

Electrochemical Power Sources

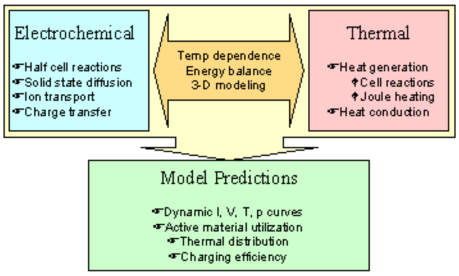
Battery and Vehicle Testing

Hawaii Natural Energy Institute (HNEI) researchers in the Electrochemical Power Systems Laboratory [1] (EPSL) have been engaged in battery and fuel cell development since 1989. The group's activities focus on solid state ionics and solid state electrochemistry, with strengths in the study of thermodynamic and kinetic properties of electrochemical power systems, including advanced batteries, ultracapacitors, and fuel cells. A major goal of the lab is to effectively utilize instrumentation together with advanced computer simulations and controls to facilitate development of electrochemical power systems for energy storage and conversion applications.

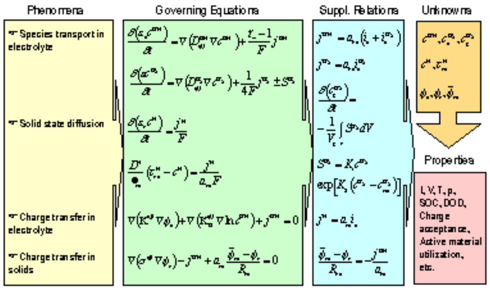
Battery Life Prediction

Research on battery life prediction involves developing a reliable, computable, and fast predicting tool for battery life through a full understanding and characterization of the nature of primary deterioration and failure processes in valve-regulated lead acid (VRLA), nickel metal hydride (Ni-MH), and lithium-ion batteries used in electric or hybrid electric vehicle (EV or HEV) applications. Researchers use an integrated laboratory investigation and advanced simulation approach, based on computational fluid dynamics (CFD) techniques or phenomenological equivalent circuit-based modeling (ECM), to develop accurate life-prediction models that incorporate the behaviors of battery deterioration and failure processes. This unique approach allowed us to:

- Develop a predictive tool to allow accurate, reliable, and non-destructive determination of battery life;
- Validate accelerated testing results based on elevated temperature protocols by comparing these results with life test data conducted under typical duty cycles at ambient temperatures; and
- Improve accelerated testing techniques at elevated temperatures though carefully analyzed primary fundamental failure mechanisms for each battery type.

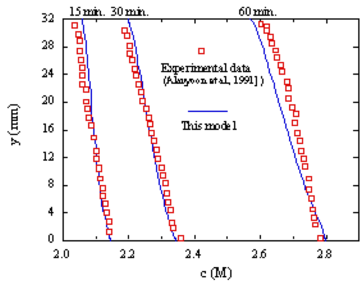


- Power control strategy
- Advanced charging algorithm development
- Cycle life prediction
- Thermal management

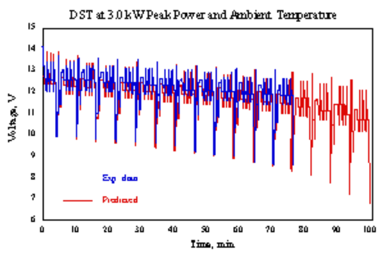


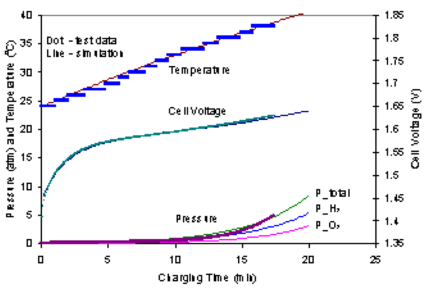
Dynamic VRLA Systems Performance:

Acid stratification

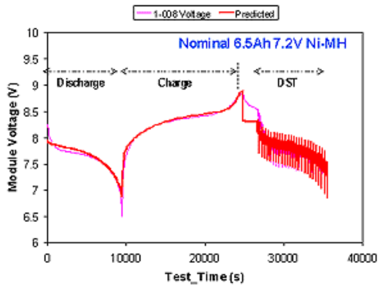


DST test profiles

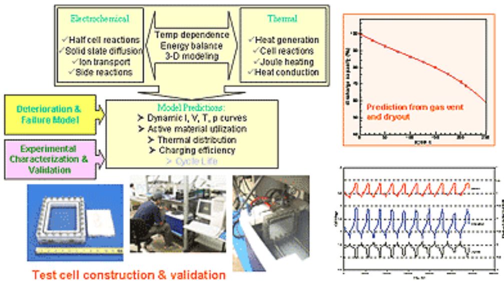




Rapid charge GMO 85Ah Ni-MH @ 2C

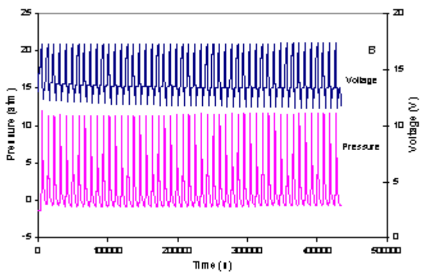


The techniques and modeling capabilities developed through this work will lead to improved battery life performance and safe operation of advanced EV or HEV batteries.

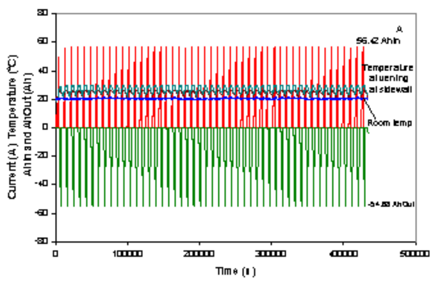


Rapid Charging Technology

The project was supported by the Defense Advanced Research Projects Agency to develop rapid-charging algorithms for advanced EV batteries that hold great potential for improved driving range and mobility. Electrosource's Horizon 12H85 valve-regulated lead acid (VRLA) battery and General Motors-Ovonic's nickel metal hydride (Ni-MH) battery (below) have been investigated to understand their rechargeability and limitations for rapid-charging. The results have led to an U.S. Patent (6,437,542) issued for rapid charging control using a unique pressure control approach.



Pressure-Control Algorithm



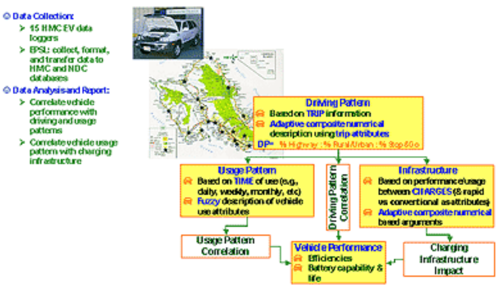
Reproducible Rapid Charge Over 250 deep cycles

Rapid charging technology has been recognized as an important aspect of the EV infrastructure. The benefits of rapid charging include greatly reduced recharging time (typically under 15 minutes), significantly enhanced vehicle mobility and usability, prolonged battery life, and potentially reduced life-time operating costs.

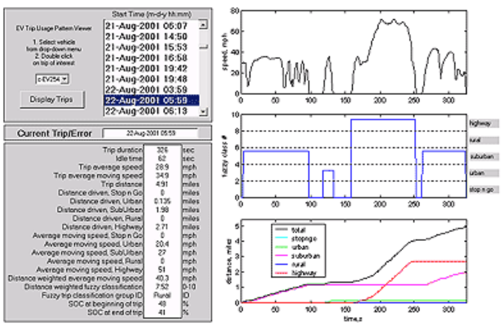
HNEI researchers are developing rapid charging techniques for all types of batteries. The approach is unique: a sophisticated and effective battery simulator has been developed using computational fluid dynamics (CFD) codes that can model battery behaviors for different types of chemistries. The simulator can also model overcharging conditions and thermal behaviors, making it suitable for studying charging in general, and rapid-charging in particular. Combined with HNEI's advanced battery research and development capabilities, this approach can drastically reduce the development time for rapid charging protocols.

Researchers are also developing optimized charging strategy for various chemistries; improved battery rechargeability; battery cycle life prediction; battery thermal management; and battery design, scale-up, and operation.

Electric Vehicle Field Data Collection and Analysis



Since July 2001, researchers have been working with HEVDP, Hyundai Motor Company, Enova Systems, and fleet operators in Hickam Air Force Base, City and County of Honolulu, Hawaiian Electric Company, to jointly conduct field testing of 15 Santa Fe electric sports utility vehicles on Oahu. Real-time trip and charging data were collected with on-board data loggers. An innovative analytical tool was developed to analyze driving cycle compositions of the trips collected on the vehicles. The driving pattern analysis is used to correlate the vehicle performance data to help develop information on how the vehicle is being used and how the usage will affect the vehicle performance and battery life. This is the first time that field trip data can be systematically analyzed for such type of analysis at this scale.



Novel Fuel Cell Development
(Low-to-Intermediate Temperature Solid Oxide Fuel Cell)

Researchers are seeking to bridge the gap between conventional proton exchange membrane and solid oxide fuel cells by developing compact fuel cell configurations that can operate in the low to intermediate temperature ranges to improve efficiency and simplify operating requirements. Advanced material preparations and cell configurations are being studied in contrast to conventional approaches. Thin film configurations, in particular, are being examined to aid in the development of unique, compact cell functionality that can facilitate lower temperature operation. Research will concentrate on new electrolyte compositions and preparations, new anode and cathode compositions and preparations, and new cell configurations to simplify the fabrication process and operation.

For further information concerning Electrochemical Power Sources activities, contact Bor Yann Liaw [2].

Last Updated: Monday, March 11, 2013
Tags: batteries [3]

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