National Aeronautics and Space Administration

Power Generation and Storage

Model-Based Prognostics For Batteries

Prognostics and estimation of remaining useful life of energy storage devices

Battery-powered devices have become ubiquitous in the modern world, from tiny headsets, to cameras, cell phones and laptops, to hybrid and electric vehicles. Effective Battery Health Monitoring (BHM) technologies are needed to ensure that battery operation is optimal and, if not, that it stays within design limits and warnings are provided to operators or automated actions are taken to mitigate damage when these limits are exceeded. BHM technologies protect the asset's batteries from degradation due to non-optimal usage, and ensure viable levels of system availability, reliability and sustainability in the presence of degraded batteries.

Prediction of the Remaining Useful Life (RUL) of a system's component is at the center of effectively managing a system's health. This invention provides as many as eight different prognostic modes for estimating the state of charge, state of life, end of discharge, and/or end of life of a battery. These estimates help in making predictions of the remaining useful life for individual discharge cycles as well as for cycle life.

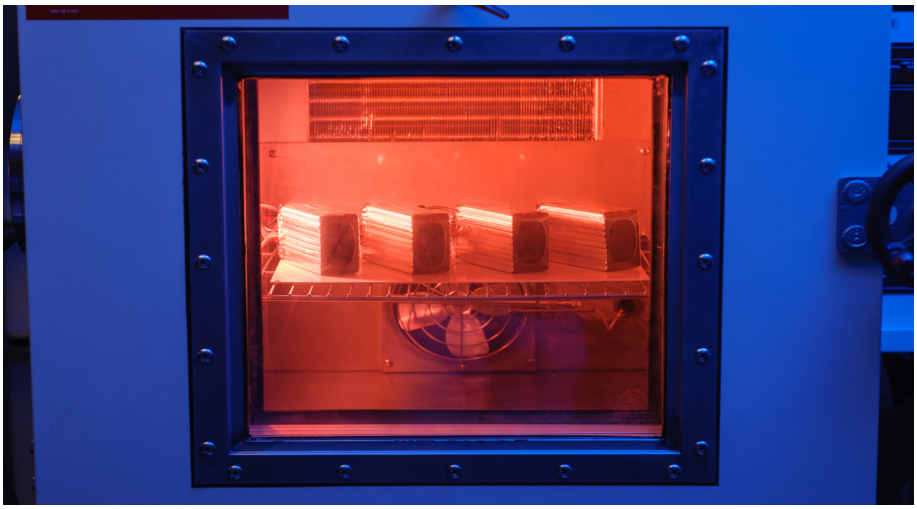
BENEFITS

- Provides enhanced health management routines for batteries
- Provides mathematical rigorous reasoning framework for better understanding, representation, manipulation, and management of the various sources of uncertainty inherent in prognostics of battery remaining useful life
- Allows a variety of models to be accommodated
- Produces remaining useful life PDF-formatted reports as output–a more individualized representation of the real condition than statistics such as mean time between failure of battery health
- Provides accurate gauge for remaining electrical charge and for trade-offs in longterm durability and shortterm usage needs

technology solution

THE TECHNOLOGY

This invention relates to the prediction of the remaining useful life of an object in use. It develops a mathematical model to describe battery behavior during individual discharge cycles as well as over its cycle life. The models used to estimate the remaining useful life of batteries are linked to the internal electro-chemical processes of the battery. The effects of temperature and load have been incorporated into the models. Model validation studies were conducted using data from a series of battery cycling experiments at various thermal and electrical loading conditions. Subsequently, the model has been used in a particle filtering framework to make probabilistic predictions of remaining useful life for individual discharge cycles as well as for cycle life.



Battery environmental chamber

APPLICATIONS

The technology has several potential applications:

- Commercial concerns using batteries as the primary (or backup) power source for their product
- Commercial concerns pursuing research and development for prognostic health management/ condition-based maintenance
- Manufacturers of primarily batterypowered vehicles for land, air, and water
- Companies developing software products for system health management

PUBLICATIONS

U.S. Patent 8,332,342

U.S. Patent 8,725,456

”Model-based Prognostics with Concurrent Damage Progression Processes,” 2013, IEEE Transactions on Systems, Man, and Cybernetics, Part A : Systems, Vol. 43 No. 4, 535-546.

More Information

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