Thermal Characterization of Advanced Lithium-Ion Polymer Cells

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Project Objective

The objective was to develop a Lithium-ion (Li-ion) polymer cell with desirable thermal characteristics for use in advanced automotive applications. The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) collaborated with Compact Power Inc. (CPI) to thermally characterize and analyze three generations of CPI/LG Chem prototype Li-ion polymer cells.

The Importance of Thermal Characterization

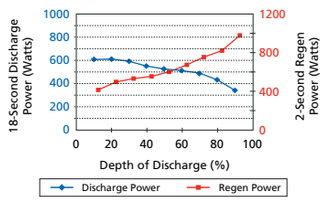
The performance, life-cycle cost, and safety of electric, hybrid electric, and fuel cell vehicles (EVs, HEVs, and FCVs) depend on the performance and life of their energy storage systems. LG Chem and CPI have been developing large Li-ion polymer cells and batteries for EV, HEV, and other applications.

Data on the thermal behavior of polymer cells, such as heat generation rate and temperature non-uniformity under a specified power cycle, are needed to verify the expected thermal performance of the cells and to improve the cell and pack thermal management system.

CPI/LG Chem Li-Ion Polymer Cells

Cell	Ah capacity (Ah)	Max discharge current (amps)	Mass (grams)	Specific energy (Wh/kg)	Size (mm) (L x W xH)
Generation 1	4.5	45	144.6	118	105 x 125 x 3
Generation 2	5.0	75	201.3	94	122 x 118 x 11
Generation 3	8.0	140	300.8	95	243 x 125 x 6

Power capability of the CPI Generation 3 cell under HPPC profile



Anode: High-capacity artificial graphite

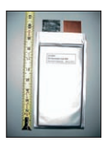
Cathode: Spinel lithiated manganese-dioxide

Assembly: Anodes and cathodes are laminated together with a separator and assembled using a proprietary winding-stacking technique.

Generation 1
- Low current rate
- Cycle-life: 95% after 200 cycles

Generation 2
- New cathode material
- Improved fabrication technique to improve cycle-life
- High power (~2000 W/kg)

Generation 3
- Larger tabs for less heat generation
- Improved packaging/ sealing processes
- Lower cell impedance with better electrodes
- High power (2,000 W/kg) with high cycle-life.



Approach

NREL used its unique capabilities to thermally characterize the Li-ion cells.

Heat Generation Testing

Measured heat generation rate from the cells under various charge/discharge profiles and temperatures: constant current discharge at a C/5, C/1, 2C, and 6C rate until voltage reached CPI's specified lower voltage limit (3.0 V) – 100% state of charge (SOC) to 0% SOC.

NREL used its large conduction calorimeter (left) to measure heat generation.

At right is a top view of the inside of the calorimeter.

Thermal Imaging and Analysis

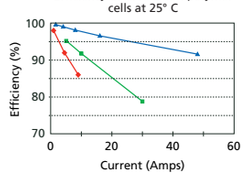
Thermal imaging setup

Obtained thermal images of cells under load to determine the location of hot spots and points of concern: cell was fully discharged from 100% to 0% SOC and the thermal image was taken during discharge.

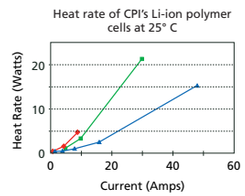
Results

Heat Generation Testing

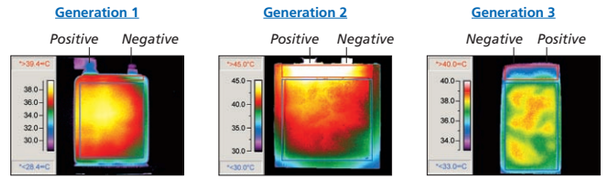
Efficiency of CPI's Li-ion polymer cells at 25° C



Heat rate of CPI's Li-ion polymer cells at 25° C



Thermal Imaging and Analysis



Thermal images taken at the end of discharge show localized heating in the first two generations of cells and relatively uniform temperatures in Generation 3.

Cell	Current (Amps)	Active Area (blue box in thermal images)		Area between bottom of electrodes and active area (red box in thermal images)	
		Min. Temp. (°C)	Max. Temp. (°C)	Min. Temp. (°C)	Max. Temp. (°C)
Generation 1	9.0	33.0	38.6	29.6	37.0
Generation 2	30.0	34.0	47.5	39.4	>50.0
Generation 3	30.0	35.7	38.7	32.2	37.0

Conclusions

- Heat generation as a function of current decreased with each successive generation of cells owing to lower internal resistance.
- Efficiency as a function of current increased with each successive generation of cells.
- Generation 1 and 2 cells showed localized heating during discharge, whereas the Generation 3 cell remained relatively uniform in temperature.
- Generation 3 cells have demonstrated good cycle-life, high power (2,000 W/kg), and high specific energy (95 Wh/kg).
- CPI has developed battery packs based on Generation 3 cells for HEV applications.

For more information:

www.ctts.nrel.gov/BTM/
www.lgchem.com
www.compactpower.com