Simplifying Thermal Management for EVs for Greater Range

For electric vehicle users, battery range and life are everything. Lose performance on either of these two metrics, and you've suddenly got a riot on your hands. As electric vehicles and plug-in electric hybrid vehicles become more sophisticated and demands for greater battery efficiency and range increase, the need for maintaining optimal battery temperatures become vastly more important. This is especially true given the current quest for rapid charging options, which tend to heat up batteries faster, thereby potentially shortening their life.

A battery that can function within the right temperature ranges will last longer, require fewer charges, and provide a higher driver satisfaction rating. As such, researchers and manufacturers are working hard to find the most innovative and effective methods for intelligent thermal management for the expensive EV batteries.

Smart Thermal Management for EV / HV Batteries

Temperature plays many roles within an electric vehicle, but perhaps most important for those that rely on batteries for their power is the capacity loss batteries experience as a result of overheating. This has been a particularly thorny issue for the popular lithium ion batteries which do not fare well in hot weather.

In fact, battery thermal management has become a significant problem for the Nissan Leaf recently when Phoenix area Nissan Leaf owners reported concerns over relatively rapid loss of battery capacity and premature battery pack aging. The speculation is that the extreme heat in Phoenix is at least in part to blame (the Leaf's air cooling system can't seem to keep up), leading to a renewed interest in battery thermal management in order to ensure a longer battery life.

In response to what was seen as a lack of follow-up from Nissan about their complaints, a Leaf owner-organized event in 2012 saw 12 owners gather together in Arizona to do a test of their own to determine if heat had an impact on battery capacity. After fully charging each vehicle, they went (one at a time) through a mapped route until their batteries ran completely out of energy. The driving was done at night, and once the drives were completed, measurements of total charge, expected range, and actual range were taken.

The results showed a variety of ranges, from 80 miles for the newest, lowest-mileage vehicles to only 59.3 miles for some of the older vehicles. Full results can be seen at InsideEVs, with detailed analysis from several of the engineering-inclined drivers.[i] The moral of the story is that clearly, overheating has a negative impact on these types of batteries. Nissan has being responding to customer concerns with many reassurances that they are looking into the issue, and certainly they'll develop solutions for overcoming this challenge.[ii]

In the meantime, many other companies are touting their battery thermal management systems as a way to overcome ambient temperature implications for battery life. One of these companies is Coda Automotive. Their technology of choice is an active cooling system that is said to preserve battery pack capacity and provide better performance, regardless of the climate.

It works by employing a smart temperature management system separate from cabin temperature control, which helps to keep the battery back within a set range of temperatures for optimal performance. Coda's test results indicate that their system results in a much lower rate of degradation compared to other battery systems.

You'll also find some innovative techniques being used in Tata's Indica Visa Electric vehicle. Their approach is to use three high-voltage density super polymer lithium ion batteries that are lightweight and able to avoid thermal runaway effects.[iii]

A123's Nanophosphate EXT Technology

Visteon Corporation is another example of a company leading the smart thermal management industry. They recently launched products that promise to provide greater battery thermal management for electric and hybrid vehicles. Visteon's coolant-based contact heat exchangers, for instance, are

used for both battery heating and cooling. It starts with a battery heat exchanger which is connected to the air conditioning system to reject battery heat into the coolant.

The heat from a lithium-ion battery is transferred into the coolant system. This coolant is then cooled by the air conditioning system through Visteon's coolant-to-refrigerant battery chiller when the battery needs to be cooled. The process reuses current heat exchanger technology. When heating is needed for the battery, the coolant-immersed heaters turn on. The company touts these new technologies as a boon for both the management of battery temperatures within tight ranges, as well as a way to extend battery life and improve fuel economy in hybrid vehicles.[iv]

Behr has also been a leader in this field. Their Behr chiller has been used in the Chevrolet Volt and the Opel Ampera. They are also working on several types of cooling concepts for lithium ion batteries, with an emphasis on those technologies that employ refrigerants.[v]

Yet another approach to the thermal management of EV batteries is to employ smart fans. Orion Fans, for instance, has developed a smart fan that should reduce cooling power consumption by up to 30%. The "smart" fan works by using a controller to increase or decrease fan speed in response to air temperature so that only as much energy as is needed is consumed.[vi]

Orion Smart Fan

Finally, consider the HeatReCar project (of which Fiat and others are taking part). Their goal is to explore ways to find efficient ways to harvest waste heat. One of their concepts is to recover thermal energy from vehicle exhaust heat to produce enough power to alleviate the alternator or provide powertrain support in a hybrid electric vehicle.[vii]

Leap-Frogging Temperature Challenges with Innovative Battery-Saving Techniques

One approach to solving a problem is to use materials that leap over the original problem. This is the approach being taken by A123 Systems with their Nanophosphate EXT technology which is said to reduce the need for a thermal management system altogether. [Note: the company is going through a financial

restructuring so there are concerns about availability of their technologies in the future.] They argue that a thermal management system can drain energy from the battery in order to power the heating and cooling system. Their solution is to use materials that can operate in a wider range of temperatures without changes in power capability. Their nanotechnology-based lithium ion battery can operate well over a wide range of temperatures reliably with 2-3x the cycle life of a conventional lithium ion battery.[viii]

If the battery type is a problem, why not choose a different composition – one that's not as susceptible to temperature issues? GM is playing with ideas for how keeping battery temperatures in the ideal range with their new Spark model which will use a lithium-iron phosphate battery. This battery has low electrical resistance that generates less heat and prolongs its life. The vehicle will also employ liquid cooling to maintain optimal battery temperature.[ix]

Consider, also, the Fraunhofer Institute for Environmental, Safety, and Energy Technology's CryoSolplus phase-change battery coolant. This material is made of water, stabilizing tensides (detergents), paraffin, and glycol anti-freeze. When cool, the paraffin is solid in droplet form and suspended uniformly by the tensides. As the temperature rises, the droplets melt, thereby storing the heat.

The material is circulated in pipes that surround the EV batteries, allowing for the continual removal heat from the battery system. CryoSolplus conducts heat much more efficiently than water, which means less of it is required to maintain an optimal temperature for the batteries. This reduces the coolant tank size and lowers the weight of the vehicle, which is, of course, important for electric cars. The good news is that estimates put this type of cooling system at only €50 to €100 (US$61-$122) more than a water-based cooling system.[x]

Conclusion

Clearly there are many approaches to solving battery temperature challenges, with many materials, technologies, and engineering solutions each offering benefits. Given the relatively large role batteries play in the cost and effectiveness of electric vehicles, it's imperative these challenges get solved sooner rather than later.

Maryruth Belsey Priebe

A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn more about Maryruth's work by visiting her site, www.jadecreative.com.

Sources

[i] *Nissan Leaf owners stage massive test to prove battery aging case*. (2012, September 20). Retrieved February 12, 2013, from Torque News: http://www.torquenews.com/1080/nissan-leaf-owners-stage-massive-test-prove-battery-aging-case

[ii] *Nissan responds to Leaf owners worries about battery capacity loss*. (2012, July 24). Retrieved February 12, 2013, from Torque News: http://www.torquenews.com/1075/nissan-responds-leaf-owners-worries-about-battery-capacity-loss

[iii] BrainMedia. (2012, August 14). *Tata To Come Up With Indica Vista Electric Car In 2013*. Retrieved February 20, 2013, from New Upcoming Cars: http://newupcomingcars.com/tata-to-come-up-with-indica-vista-electric-car-in-2013/

[iv] *Visteon Launches Thermal Management Products for Lithium-ion Batteries in Hybrid and Electric Vehicles*. (2012, September 26). Retrieved February 12, 2013, from Visteon: http://visteon.com/media/newsroom/2012/120926_story1.html

[v] *Annual Report 2011: Heat up. Cool down.* (2011). Retrieved February 20, 2013, from Behr Group: http://www.behrgroup.com/internet/behrmm.nsf/lupgraphics/Behr_GB_2012_Internet_E.pdf/$file/Behr_GB_2012_Internet_E.pdf

[vi] *Orion Fans Enhances Electric Vehicle Battery Compartment Cooling with Smart Fans*. (2012, Sepember 17). Retrieved February 12, 2013, from Orion Fans:

http://www.orionfans.com/images/stories/pdf/press/ke731-electric-vehicle-batter-cooling-pr.pdf

[vii] *Reduced Energy Consumption by massive thermoelectric waste heat recovery in light duty trucks*. (2012). Retrieved February 20, 2013, from Termo-Gen AB: http://www.termo-gen.com/pages/heatrecar.html

[viii] *Nanophosphate® EXT Lithium Ion*. (n.d.). Retrieved February 12, 2013, from A123 Systems: http://www.a123systems.com/lithium-ion-battery-technology.htm

[ix] Blanco, S. (2012, November 16). *Chevy Spark Electric Vehicle Prototype*. Retrieved February 13, 2013, from Autoblog Green: http://green.autoblog.com/2012/11/16/chevy-spark-electric-vehicle-prototype/

[x] Coxworth, B. (2012, July 13). *CryoSolplus could help keep EV batteries cool*. Retrieved February 13, 2013, from Gizmag: http://www.gizmag.com/cryosolplus-ev-battery-coolant/23315/