Industry Developments:

EV Battery Thermal Management

As electric vehicles and hybrid electric vehicles become more sophisticated, demands are growing for greater battery efficiency and life, and longer driving range. Achieving this must include improvements in thermal management.

There is a critical need for maintaining optimal battery temperatures. Engineers are working on more innovative and effective methods for intelligent thermal management for expensive EV and HEV batteries. A battery that can function within the right temperature range will last longer and need fewer charges. This is especially true given current demands for rapid charging, which can heat up batteries faster, thus potentially shortening their life. [1]

Figure 1. Under-Construction Lithium-Ion Battery Pack for Use in a Tesla Roadster [2]

The topic of EV thermal management has its own convention, the International Thermal Management for EV/HEV Conference. It was recently held in Germany in June 2013. A central topic at this conference and of continuous concern in the EV industry is battery thermal management. In particular, improving the thermal management of EV batteries could improve vehicle range and lead to more comfortable climates for passengers.

Temperature plays many roles inside an electric vehicle, and among the most important is the power loss that batteries experience as a result of overheating. This has been seen with the popular lithium ion batteries, which do not fare well in hot weather without a thermal management system in place.

A real world example occurred when some Nissan Leaf owners in Phoenix reported rapid loss of battery capacity and premature battery pack aging. The driving ranges varied widely when tested over a mapped route until the batteries ran completely down. The speculation was that the extreme heat in Phoenix posed an added challenge to the Leaf's air cooling system. Phoenix-based testing of Chevrolet Volts, whose batteries are liquid-cooled, showed better results.

For EVs, the driving range can also be reduced significantly when the AC system is in continuous use. In Summer, the driving range can be reduced to about 50% not only due to higher battery

temperature but also from the energy consumption of the AC system. Air conditioners in EVs should use all available heat sources and heat sinks in and outside the vehicle in order to cover all tasks in connection with heating, cooling and clearing the windows.

An important challenge is how to cope with the capacity of the high voltage battery system, which should be used mainly for driving and not for AC functions. The challenge gets bigger in cold weather because EVs generate less waste heat than vehicles with conventional drive trains. Every effort has to be made to use all available heat sources and heat sinks in and outside the car to fulfill the requirements of air conditioning. This includes the use of heat pumps. A perfect system will also control the temperature of the battery system in order to optimize the battery function. [3] While Nissan, Chevy and other EV manufacturers are taking on battery thermal management issues, some companies have introduced their own systems.

Figure 2. The Nissan Leaf's Air-Cooled Battery Pack is Under the Vehicle's Floorboard [4]

Dana Corporation offers a family of electric and hybrid vehicle cooling products that can be custom-designed for each vehicle's requirements. Components include a battery cooling chillers and cooling plates, along with cooling systems for stator coils and engine control units.

CODA Automotive developed an active cooling system to preserve battery pack capacity and deliver needed performance regardless of the climate. The system employs a smart temperature management system that's separate from cabin temperature control. This allows the battery pack to remain within the temperature range for optimal battery performance. [5]

Figure 3. The CODA Vehicle Features an Air-Controlled Active Thermal Management System [6]

Visteon Corporation provides coolant-based contact heat exchangers for both battery heating and cooling. Visteon's coolant-based solution employs a battery cooling and heating architecture, in which heat from the lithium-ion batteries is transferred into the coolant system. When the battery needs to be cooled, the air conditioning system is used to decrease the temperature of the coolant. This is made possible by Visteon's coolant-to-refrigerant battery chiller, which reuses current heat exchanger technology in an innovative and cost-effective design solution. When battery heating is needed, Visteon heaters immersed in the coolant turn on. [7]

Another manufacturer, A123 Systems has developed Nanophosphate EXT technology, which the company says can reduce or eliminate the need for any thermal management system. At the heart of this technology is a specially-designed lithium ion battery that operates over a wide temperature range, particularly at low temperatures, with 2 to 3 times the cycle life of conventional lithium ion batteries. [8]

Figure 4. Nanophosphate EXT Chemistry from A123 Systems Could Reduce or Eliminate Cooling Systems for Lithium-Ion Batteries in EVs and HEVs [9]

A new coolant. CryoSolplus, is available for keeping batteries cool. The material is a dispersion that mixes water and paraffin along with stabilizing tensides and the anti-freeze agent glycol. CryoSolplus can absorb three times as much heat as water, and functions well as a buffer in extreme situations such as trips on the freeway at the height of summer. This means that the holding tank for the coolant can be much smaller than those of water cooling systems – saving both weight and space under the hood. In addition, CryoSolplus is good at conducting away heat, moving it very quickly from the battery cells into the coolant. The coolant was developed by researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen. [10]

Figure 5. CryoSolPlus Material Could Enhance the Heat Absorbing Ability of EV Battery Liquid Cooling Systems [11]

Battery thermal management will continue to be a key area for improvement in EVs. These include intelligent systems that account for both outside and cabin temperatures and deliver improved mileage and battery life.

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