ecoENERGY Innovation Initiative
Public Report

Project ETRE 024:

Development of Thick Film Electric Heaters for Thermal Modulation of Battery Systems

Project Proponent:

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1.0 Project Summary

Temperature control in electric vehicle battery systems remains a major challenge in maximizing battery life and reliability.[1,2] To achieve improved temperature control, the Proponent of this project, Oakville Ontario based Dana Canada Corporation - a global leader and supplier of high performance compact heat exchangers for passenger car and light truck applications, has developed and manufactures today novel battery coolers to manage excess heat generated during battery charging and discharging. However, battery function and durability is also significantly compromised in cold climate conditions such as those encountered during Canadian winters.[3] Accordingly, there is a need for improved battery cooling heat exchangers that can also function as heaters to improve battery system performance operating in cold temperatures.

The goal of project ETRE 024 is to develop and integrate directly into lightweight aluminum battery cooling heat exchangers, sol gel thick film electric heaters to allow both heating and cooling functionality. To accomplish this, the Proponent has collaborated with a partner company Datec Coatings Corporation headquartered in Mississauga, Ontario, who has developed composite sol gel technologies that include laminated thick film electric heater structures. The Proponent's objective is to adapt and optimize such sol gel heater laminates for design and manufacturing integration into Dana's heat exchanger products; and thereby to achieve improved thermal modulation of automotive high voltage battery systems.

The ETRE 024 project scope included the development of suitable resistor materials and circuitry design, coating application process optimization, and design and manufacturing integration of the heater film into battery thermal modulation products. Several iterations of heater film formulations and architectures were assessed, downselected and optimized; and their performance and durability when applied to battery heat exchanger prototypes assessed via performance simulation modelling and testing, and by thermal cycling and mechanical tests conducted in simulated automotive application. Meetings and technical presentations were held with potential automotive customers, to demonstrate product capabilities, and to obtain feedback on potential system integration needs.

During the course of ETRE 024 project life, the Proponent completed the planned project scope and delivered on its core objectives. The Proponent and partner company Datec have successfully designed and developed high performance customer demonstration battery heater/cooler prototypes capable of rapid heat up rates, high efficiencies, and durability and reliability at low cost. Further phase collaborative product development activities have been established with potential customers, and are currently ongoing. If successful, these are expected to enable wider scale sustained production of cost reduced, improved performance, energy efficient battery systems, and a corresponding increased market uptake of electric and hybrid electric vehicles and associated GHG reductions.

[1] K. Smith, M. Earleywine, E. Wood et al., *Comparison of Plug-In Hybrid Electric Vehicle Battery Life Across Geographies and Drive Cycles*, 2012 SAE World Congress, April 2012

[2] A. Smith, J. Burns, X. Zhao et al., *A High Precision Coulometry Study of the SEI Growth in Li/Graphite Cells*, Journal of the Electrochemical Society, 158 (2011)

[3] C. Wang, G. Zhang, S. Ge et al., *Lithium-ion battery structure that self-heats at low temperatures*, Nature, 529 (2016)

2.0 Background

Temperature control in electric vehicle battery systems remains a major challenge in maximizing battery life and reliability. To achieve improved temperature control, the Proponent of this project, Oakville, Ontario-based Dana Canada Corporation – a global leader and supplier of high-performance compact heat exchangers for passenger-car and light-truck applications – has developed and manufactures novel battery coolers to manage excess heat generated during battery charging and discharging. However, battery function and durability is also significantly compromised in cold climate conditions such as those encountered during Canadian winters. Accordingly, there is a need for improved battery-cooling heat exchangers that can also function as heaters, to improve battery system performance when operating at cold temperatures.

3.0 Objectives

The goal of project ETRE 024 was to develop and integrate sol gel thick film electric heaters directly into lightweight aluminum battery cooling heat exchangers, to allow both heating and cooling functionality. To accomplish this, the Proponent has collaborated with a partner company, Datec Coatings Corporation, headquartered in Mississauga, Ontario, which has developed composite sol gel technologies that include laminated thick-film electric heater structures. The Proponent's objective is to adapt and optimize such sol gel heater laminates for design and manufacturing integration into Dana's heat exchanger products; and thereby to achieve improved thermal modulation of automotive high-voltage battery systems.

4.0 Research Methods

The ETRE 024 project R&D approach included the development of suitable resistor materials and circuitry design, coating application process optimization, and design and manufacturing integration of the heater film into battery thermal modulation products. Several iterations of heater film formulations and architectures were assessed, downselected and optimized using experimental material and process development trials and suitable analytical methods. The performance and durability of candidate film heaters when applied to aluminium battery heat exchanger prototypes were assessed via performance simulation modelling and testing and by durability tests conducted in simulated automotive application. Meetings and technical presentations were held with potential automotive customers to demonstrate product capabilities and to obtain feedback on potential system integration needs.

5.0 Benefits to Stakeholders

The achieved product development improvements and continued further-phase customer engagement projects have created a new and promising opportunity path to commercialize improved-battery thermal-modulation systems using technology and products developed in Canada by the Canadian Proponent and partner company Datec. If successful, these product improvements are expected to benefit Dana and Datec commercially in terms of increased revenues and added-value products.

During the course of the ETRE 024 Project, Dana and Datec have each been able to retain and/or add HQP's to their development staff to execute the associated R&D; and the Proponent Dana has been able to invest in sophisticated new analytical capabilities that will have value to continue further development of the thermal modulation/ heater products.

6.0 Benefits to Canada

The achieved product development improvements and continued further-phase customer engagement projects have created a new and promising opportunity path to commercialize improved automotive battery thermal-modulation systems using components developed by the Canadian Proponent and partner company Datec. If successful, these product improvements are expected to enable wider scale sustained production of cost-reduced, improved-performance, energy-efficient battery systems and a corresponding increased market uptake of electric and hybrid electric vehicles and associated GHG reductions.

During the course of the ETRE 024 Project, Dana and Datec have each been able to retain or add HQP staff to their Canadian R&D facilities.

7.0 Lessons Learned

The funding support provided by the Government of Canada via the ecoENERGY Initiative has been critical for the successful completion of Project ETRE 024. Without it, the Proponent Dana would not have been able carry out the project or establish partner relationship with Datec. Consequently, HQPs retained and added at Datec, as well as the opportunity to expand the battery thermal-management market, would have been lost.

The developed product concepts are somewhat disruptive, so that customer uptake took longer than anticipated to consider system integration needs and to establish suitable system level testing protocols. Remaining technical challenges include heater control integration into the battery management system

8.0 Outcomes

During the course of ETRE 024 project life, the Proponent completed the planned project scope and delivered on its core objectives. The Proponent and partner company Datec have successfully designed and developed high-performance customer-demonstration battery heater/cooler prototypes capable of rapid heat up rates, high efficiencies, and durability and reliability at low cost. Further-phase collaborative product-development activities have been established with potential customers and are currently ongoing. Based on this, Dana considers that a new and promising opportunity path has been generated to commercialize improved automotive battery thermal-modulation components and systems.

9.0 Next Steps

Dana and its partner Datec are continuing to support further development activities with engaged customers, building on the success of demonstration prototypes achieved to date.