# ecoENERGY Innovation Initiative
# Public Report

Project ETRE 010:

**Improved Fluxless Aluminium Brazing Materials and Process Technology for Manufacturing of Advanced Battery Cooling Heat Exchanger**

Project Proponent:


**Dana Canada Corporation**
656 Kerr Street, Oakville, ON L6K 3E4, Canada


May 31st, 2017

# Contents

# 1.0 Project Summary

Improved thermal modulation of lithium ion batteries is a critical need for battery life and operating reliability, and is a key enabler for market adoption of battery and hybrid electric vehicles.[1,2] The Proponent, 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 an early market lead position in the supply of first generation battery cooling heat exchanger products, based to a large extent on its existing proprietary fluxless aluminum brazing technology that it has previously commercialized for traditional heat exchanger manufacturing.

The Proponent's early battery cooling experience has revealed several critical manufacturing challenges that will need to be overcome to sustain their early lead position. Battery systems require exceptionally high levels of cleanliness and freedom from even trace levels of ionic contamination, and preferred configurations require the brazing of extremely thin aluminum panels with high surface areas of internal joints. The objective of Project ETRE 010 is to improve the constituent technologies involved in a fluxless aluminum brazing process, to achieve improved gains in braze efficacy in thin material systems, to accommodate constraints related to the battery cooler product configurations, and to increase processing speeds while reducing cost and improving environmental efficiencies.

The scope for project ETRE 010 included collaborative work with Canadian university partners to optimize recently developed new braze reaction kinetics measurement methods for the development of new nickel (Ni) braze promoter and aluminum material systems, structures and improved deposition processes. A comprehensive study of the effects of various joining variables; such as, the aluminum braze material chemistries, surface pretreatment methods, and plating formulations were carried out. New material characterization and thermal analysis tools and methodologies were developed to achieve a more in-depth understanding of the Ni-based braze promotor deposition process and fluxless braze mechanism. To integrate the laboratory-gained advances for pilot level scale-up, an existing prototype continuous strip plating pilot was redesigned and rebuilt for further process development and optimization activities.

During the course of ETRE 010 project life, the Proponent has completed the planned project scope and delivered on its core objectives. An improved fluxless brazing pilot process, with an improved surface pretreatment process and environmentally friendlier braze promoter formulation was developed, optimized and validated under simulated production conditions. A medium high confidence level was achieved, and the Proponent is on track to commercialize and deploy this new and improved technology for the manufacture of next generation battery coolers.

[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)

## 2.0 Background

Improved thermal modulation of lithium ion batteries is a critical need for battery life and operating reliability and is a key enabler for market adoption of battery and hybrid-electric vehicles. 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.

The Proponent's early market lead position in the supply of first-generation battery-cooling heat exchanger products for such battery systems is based to a large extent on its existing proprietary fluxless aluminum brazing technology previously commercialized for traditional heat-exchanger manufacturing. However, the Proponent's early battery cooling experience has revealed several critical manufacturing challenges that will need to be overcome, including improving the braze system performance on very thin gauge aluminum sheets, environmental efficiencies, and manufacturing speeds and cost.

## 3.0 Objectives

The goal of Project ETRE 010 was to improve the constituent technologies involved in a fluxless aluminum brazing process, to achieve improved gains in braze efficacy in thin-material systems to accommodate constraints related to the battery cooler product configurations, and to increase processing speeds while reducing cost and improving environmental efficiencies. The Proponent's objective is to develop a new and improved Ni plating process with a more environmentally friendly braze promotor formulation and deposition process for improved product brazed efficacy, process robustness and costs.

## 4.0 Research Methods

The ETRE 010 project R&D approach included the development and optimization of several iterations of Ni-based braze promoter formulations and surface pretreatment methods. Advanced material characterization methods, electrochemical analysis and braze kinetic studies on laboratory generated coupons and testing were carried out. The development and optimization of advanced thermal analysis methodologies for braze reaction kinetics measurement was performed in collaboration with Canadian university partners, the University of Waterloo, Waterloo, Ontario, and the University of Dalhousie, Halifax, Nova Scotia. The laboratory-gained advances were integrated into a redesigned and rebuilt continuous-strip pilot plating line for further process development and optimization iterations for simulated product-level braze trials and testing.

## 5.0 Benefits to Stakeholders

The development of the new and optimized prototype Ni-based brazed promoter and pilot plating process has resulted in the generation of new intellectual property and expansion of core competencies in fluxless-materials joining technology for battery cooling and broader heat-exchanger application. Some of the knowledge gained has been applied to the current production of thin-gauge battery coolers and resulted in significant improvements in scrap and costs. Upon successful commercialization and deployment of this new manufacturing technology in the near term, the Proponent Dana is expected to benefit commercially via overall improved heat-exchanger manufacturing costs, process robustness and environmental impact, as well as via increased production and growth of lower-cost next-generation battery thermal-management systems.

During the course of the ETRE 010 project, the Proponent has been able to add HQPs to their full-time development staff to execute the associated R&D and invest in sophisticated new analytical capabilities that will have value to continue further development for new products in the future. The Proponent's university partners benefited from this project through the development of their HQPs, and intensification of their material and joining expertise that is expected to have long-lasting and sustaining benefits to the Proponent, and to the larger industry community that these universities serve.

## 6.0 Benefits to Canada

The achieved new and improved manufacturing process technology and continued development by the Proponent Dana have created a promising commercialization path to deploy this new technology for the manufacture of next-generation of battery coolers. The deployment of this new manufacturing technology for battery cooling is expected to improve production yields, lower overall manufacturing costs, and increase the market uptake of electric and hybrid electric vehicles and associated GHG reductions.

Since Dana's development was performed at its Oakville R&D Center and Dana's battery-cooling manufacturing plant is based in Cambridge, Ontario, growth in the Proponent's business resulting from this project is expected to create new jobs in Canada, strengthen the Canadian economy and enhance Canada's leadership in clean technologies and innovation.

During the course of the ETRE 010 Project, Dana has been able to add HQP staff at their Oakville R&D facility.

## 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 010. Without it, the Proponent Dana would not have been able to make the necessary R&D investments to progress as far and quickly as it did, and would thereby have required a significantly reduced scope and/or extended project timeline.

Remaining technical challenges include the next phase of project scale-up to commercialize and deploy the developed manufacturing process that is outside the scope of project ETRE 010.

## 8.0 Outcomes

During the course of ETRE 010 project life, the Proponent has completed the planned project scope and delivered on its core objectives. An improved fluxless brazing pilot process, with an improved surface pretreatment process and environmental friendlier braze promoter formulation, was developed, optimized and validated under simulated production conditions.

## 9.0 Next Steps

A medium-high confidence level was achieved, and the Proponent is on track to commercialize and deploy this new and improved technology for the manufacture of next-generation battery coolers.