VILLANOVA UNIVERSITY

Hybrid Cooling of Battery Cells at Module Scale with Inserted Fins

Lead Investigator

Sylvie Lorente Ph.D., Associate Dean for Research and Innovation, College of Engineering; Chair and Professor in Mechanical Engineering

Background and Unmet Need

Stationary battery systems are configured as racks containing sealed modules filled with battery cells. Similarly, configurations also are developed, such as stationary electric vehicle chargers. Charging and discharging occur through an electrochemical process within Li-ion battery cells. This process is exothermic, with more heat being generated during discharge. Depending on cell capacity, this often leads to cell temperatures and temperature differences throughout the cell beyond admissible values to maintain the integrity and life of the battery cells.

In some cases, thermal management must be provided at the module level; indeed, liquid cooling is not yet permitted to avoid the risk of contact between liquid and cells. While liquid cooling is an energy-efficient solution as compared to air cooling, current configurations are not sufficient when implemented at the scale of the modules that contain the battery cells.

A thermal management system that takes advantage of liquid cooling efficiencies, while also having the ability to be used at the scale of current and future stationary battery storage modules, will resolve industry concerns. It will substantially reduce the operational cost of free-standing storage battery systems, and will maintain those systems within the desired, targeted temperature range.

Opportunity

Dr. Lorente has invented a novel hybrid cooling system that utilizes modular ceramic insert architecture for stationary battery storage systems. The invention ensures batteries are separate from the coolant, while keeping the battery cells within the desired and targeted temperature range.

Modular hybrid cooling is achieved by an external liquid cooling network combined with a ceramic architecture to regulate heat during charging and discharging operations. The ceramics material is a dielectric of high thermal conductivity, and liquid cooling can either be single or two-phase. When the inserts are placed appropriately between the battery cells, they convey generated heat toward the top of the module for removal by the liquid cooling channels. This liquid cooling system is highly efficient; it maintains low flow rates while simultaneously extracting a large amount of heat without compromising the integrity of the modules.

Most importantly, this invention can be scaled to stationary battery storage configurations with modules that contain battery cells while maintaining proper efficiency. While originally designed for Li-ion batteries, this invention can be used for any type of battery.

The demand for thermal management systems is predicted to increase as the general stationary battery storage market rapidly expands. The stationary battery storage market is projected to grow from $71.4 billion USD to $870.4 billion USD at a CAGR of 27.2% from 2023 to 2032.[1]

Global EV charging station infrastructure is rapidly expanding. Today industry and consumers demand ultra-fast charging processes for their electrical vehicles. As a result, large amounts of

[1] Stationary Battery Storage Market Size by Battery… Forecast, 2023 – 2032, Global Market Insights, November 2022.

Continued on back

heat are generated at the battery cells level within the stationary battery energy storage stations or modules. The market is expected to grow to $217.06 billion USD at a CAGR of 30.6% from 2022 to 2030.[2]

The rapid development of the EV charging station infrastructure will drive the demand for dedicated thermal management systems for EV charging stations that are more effective and energy efficient than the current state-of-the-art air-cooling solutions.

Dr. Lorente's invention offers a novel approach, capable of fulfilling the need for dedicated thermal management solutions for any stationary battery storage system.

Unique Attributes

- Highly scalable hybrid cooling system *compatible with any battery*.
- Modular dielectric ceramic infrastructure with high thermal conductivity.
- State-of-the-art efficient hybrid cooling system with low flow rates and high heat extraction without risk of contact between coolant and battery cell.

Applications

The invention is compatible with any battery and stationary storage infrastructure, which may be scaled to accommodate any configuration. This invention is particularly useful in electric vehicle charging stations.

Stage of Development

Fully developed numerical / mathematical model of the invention.

Intellectual Property

United States Patent Application filed February, 2024.

Licensing and Collaboration Opportunity

Villanova is seeking a licensee or collaborators to commercialize or further develop the invention.

INSTITUTIONAL CONTACT

Amanda M. Grannas, Ph.D.
VP & Chief Research Officer
+1 610.519.4881
amanda.grannas@villanova.edu

L2C PARTNERS CONTACT

Merle Gilmore, MBA
+1 610.662.0940
gilmore@l2cpartners.com

Alex Toglia, MS
+1 610.937.1067
toglia@l2cpartners.com

---

[2] Electric Vehicle Charging Infrastructure Market Size, Share & Trends Analysis Report by Charger Type, by Connector, by Application, by Region, and Segment Forecasts, 2022-2030, Research and Markets, April 2022.