

OPTIMAL DESIGN OF INDIRECT LIQUID COOLING SYSTEMS FOR ELECTRIC VEHICLE BATTERY PACK

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Abstract

Thermal management stands as a pivotal challenge in the advancement of electric vehicle (EV) technology. Inefficient heat dissipation within battery packs leads to temperature non-uniformity among individual cells, which significantly accelerates capacity fade and power density degradation. Furthermore, excessive heat accumulation serves as a primary trigger for thermal runaway, posing severe safety concerns for passengers. Prismatic lithium-ion battery packs have become increasingly prevalent in the industry due to their superior mechanical strength and high volumetric energy density. However, their compact arrangement makes them particularly susceptible to localized heat buildup, necessitating a robust cooling strategy to maintain operational stability. Indirect liquid cooling systems are widely utilized to address these issues, offering an effective balance between heat removal performance and structural simplicity for large-scale manufacturing. To optimize these complex systems, surrogate model-based optimization can provide a solution to the high computational costs associated with traditional numerical simulations.

This study proposes a surrogate model-based optimization methodology to minimize the maximum temperature difference within a multi-module battery pack. The target system's design space involving cooling plate geometry, channel dimensions, and coolant flow rate was systematically sampled using a Design of Experiments (DoE) approach. By constructing a surrogate model, the design process achieved high accuracy while significantly reducing the time required for evaluation. Consequently, this study successfully identifies an optimized cooling configuration that enhances thermal uniformity throughout the battery pack.

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