

Battery Thermal Management

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ABSTRACT

Effective thermal management is crucial for ensuring the safety, efficiency, and longevity of lithium-ion batteries, particularly in electric vehicles and energy storage systems. Temperature fluctuations significantly impact battery performance, accelerating degradation and increasing the risk of thermal runaway, which can lead to catastrophic failure. This study explores a range of thermal management techniques, including passive methods such as phase change materials (PCMs) that leverage latent heat absorption, and active cooling strategies like liquid and air cooling that enhance heat dissipation through external interventions. A comprehensive analysis is conducted using both experimental investigations and computational simulations to evaluate the effectiveness of these methods in maintaining thermal stability and improving battery lifespan. The research focuses on the relationship between thermal dynamics and electrochemical performance, identifying critical temperature thresholds and distribution patterns that influence efficiency and safety. The findings emphasize the necessity of integrating advanced thermal management solutions at the design stage to optimize battery performance, mitigate overheating risks, and enhance overall energy efficiency. Additionally, this study highlights the importance of sustainable and scalable cooling strategies in the development of next-generation battery systems. By bridging the gap between theoretical advancements and practical applications, the research provides valuable insights for engineers, researchers, and industry professionals striving to enhance battery reliability and safety. The conclusions drawn from this work contribute to the ongoing pursuit of high-performance, durable, and thermally stable lithium-ion battery technologies that meet the growing demands of modern energy storage applications. Through the integration of efficient cooling mechanisms, this study aims to support the advancement of safer, more reliable, and longer-lasting energy storage solutions, ultimately facilitating the transition towards more sustainable and efficient battery-powered systems.