

A Review of Lithium-Ion Battery Thermal Runaway Modelling and Diagnosis Approaches

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Abstract

Lithium-ion (Li-ion) batteries have been utilized increasingly in recent years in various applications, such as electric vehicles (EVs), electronics, and large energy storage systems due to their long lifespan, high energy density, and high-power density, among other qualities. However, there can be faults that occur internally or externally that affect battery performance which can potentially lead to serious safety concerns, such as thermal runaway. Thermal runaway is a major challenge in the Li-ion battery field due to its uncontrollable and irreversible nature, which can lead to fires and explosions, threatening the safety of the public. Therefore, thermal runaway prognosis and diagnosis are significant topics of research. To efficiently study and develop thermal runaway prognosis and diagnosis algorithms, thermal runaway modelling is also important. Li-ion battery thermal runaway modelling, prediction, and detection can help in the development of prevention and mitigation approaches to ensure the safety of the battery system. This paper provides a comprehensive review of Li-ion battery thermal runaway modelling. Various prognostic and diagnostic approaches for thermal runaway are also discussed.

Keywords: lithium-ion battery; thermal runaway; battery modelling; fault diagnosis; internal short-circuit.

1. Introduction

The combustion of gasoline or diesel in conventional vehicles is considered one of the leading causes of climate change due to greenhouse gas emissions. Building a future that preserves the environment and reduces dependence on fossil fuels is imperative, and depends substantially on the world's transition to renewable energy. Lithium-ion (Li-ion) batteries are recognized as a sustainable, next-generation vehicle "fuel" owing to their superior features, including high energy density, high power density, long cycle life, low self-discharge rate, no memory effects [1-4], and low environmental emissions and pollution [5,6]. These advantages, especially high energy density and power density, have made Li-ion batteries suitable for successful application in electric vehicles (EVs) [3]. Global EV stock reached 10 million in 2020 and approximately 370 EV models were available worldwide in 2020, representing a 43% and a 40% increase from 2019, respectively [7]. From 2020 to 2025, the global market for Li-ion batteries is estimated to increase from USD 44 billion to USD 94 billion. Moreover, Li-ion batteries are also used in many other energy storage applications, as governments pivot towards the use of renewable energy sources, such as solar and wind, creating a need for energy to be stored. The uncontrollable and irreversible nature of thermal runaway is the main challenge for the mitigation of Li-ion battery safety hazards. It has focused researchers' attention on the prediction of thermal runaway behaviours to enable early warning or delays, to potentially prevent thermal runaway in Li-ion battery applications.