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Numerical Investigation of Immersion Cooling Performance for Lithium-ion Polymer (LiPo) Battery: Effects of Dielectric Fluids and Flow Velocity

Abstract

This study investigates the enhancement of immersion cooling performance for a single 14.6 Ah lithium-ion polymer (LiPo) battery cell by using air, palm oil, and engineered fluid (3M Novec 7000) as dielectric fluids. The research aims to observe the temperature distribution and rate of heat transfer on the battery cell at a 3C discharge rate, while varying the fluid velocity flow (0 mm/s, 1 mm/s, and 50 mm/s) and fluid types. Computational fluid dynamics (CFD) simulations were performed using ANSYS Fluent software, with heat generation from the LiPo battery simulated using the Newman, Tiedmann, Gu, and Kim (NTGK) semi-empirical electrochemical model. Results revealed that palm oil demonstrated the optimum cooling effect, reducing peak temperature to safe operating temperature region by 62.4% within 1020 seconds. Fluid flow velocity strongly influenced temperature distribution and heat transfer rates, with 50 mm/s resulting in a more uniform temperature distribution compared to 1 mm/s and 0 mm/s. The rate of heat transfer was highest at 1 mm/s and intermediate at 50 mm/s. Considering the abundance of palm oil in Malaysia, utilizing it as the dielectric fluid with a 50 mm/s flow velocity yields the best cooling effect for the 14.6 Ah LiPo battery at a 3C discharge rate.

Keywords

Air; Binary alloys; Computational fluid dynamics; Cooling; Electric discharges; Lithium; Lithium alloys; Lithium-ion batteries; Palm oil; Temperature distribution