INTISARI

Thermal runaway menjadi masalah dalam pengoperasian baterai *lithium-ion.* Ini terjadi karena proses pengisian/pengosongan dengan tingkat *C-rate* tinggi pada baterai *Li-ion*. Proses ini meyebabkan reaksi kenaikan temperatur yang berasal dari pembangkitan panas internal selama pemakaian. Banyak energi baterai yang dapat digunakan akan hilang pada temperatur tinggi karena kapasitas/daya memudar, *self-discharge*, dan hal lainnya. Untuk pengoperasian yang aman dan efisien, baterai *Li-ion* perlu dilengkapi dengan sistem manajemen termal baterai (BTMS) untuk mempertahankan temperatur optimal kisaran 15 – 35 °C dan keseragaman temperatur masing-masing LIB 0 – 5 °C sehingga memperpanjang masa pakainya. Penelitian ini menerapan metode *Immersion Cooling* dengan fluida kerja HFE-7100 pada baterai *Li-ion* tipe LFP 18650 yang dirangkai seri sebanyak 24 buah. Penelitian dilakukan menggunakan fasilitas baterai *Immersion Cooling test* dengan desain 6 channel. *Depth of Discharge* (DoD) dilakukan pada 80% kapasitas baterai selama proses *discharge* dengan variasi *C-rate* 1 C, 1,5 C, 2 C, dan 2,5 C dan laju aliran fluida 0,5 Lpm, 1 Lpm, dan 1,5 Lpm.

Hasil penelitian menunjukan metode pendinginan *Natural Convection* memiliki karakteristik temperatur permukaan dari tertinggi hingga terendah dengan susunan channel sebagai berikut 6-3-2-4-5-1 dibandingkan dengan metode *Immersion Cooling* dan *Flow Immersion Cooling* dengan aliran 0,5 Lpm, 1 Lpm, dan 1,5 Lpm yang memiliki karakteristik temperatur permukaan dari tertinggi hingga terendah dengan susunan channel sebagai berikut 6-5-4-3-2-1. Semakin besar nilai laju pengosongan *C-rate* maka akan semakin besar juga temperatur permukaan baterai dengan *Depth of Discharge* (DoD) ataupun dengan durasi waktu pengosongan yang sama. Semakin besar nilai laju aliran fluida maka akan semakin kecil temperatur permukaan baterai. Pada laju pengosongan *C-rate* 2 C *dengan* metode *Flow Immersion Cooling* mengunakan cairan HFE-7100 pada aliran 0,5 Lpm, 1 Lpm, dan 1,5 Lpm mempunyai temperatur permukaan baterai sebesar 29,4 °C, 28,2 °C, 27,8 °C, dan mengalami penurunan sebesar 11,4%, 15,1%, dan 16,3% secara berturut-turut dibanding metode pendinginan *Natural Convection.* Metode *Flow Immersion Cooling* (0,5 Lpm, 1 Lpm, dan 1,5 Lpm) mempunyai nilai rata-rata *local heat transfer coefficient* terendah ke tertinggi sebesar 899,8 W/m^2·K, 1154,8 W/m^2·K, dan 1315,2 W/m^2·K. Nilai rata-rata *local heat transfer coefficient* pada 1 Lpm, dan 1,5 Lpm mengalami peningkatan sebesar 21% dan 46% dibanding dengan laju aliran fluida 0,5 Lpm.

Kata Kunci: *Thermal runway*, sistem manajemen termal baterai, *Immersion Cooling*, HFE-7100, *heat transfer coefficient, average temperatur difference.*

ABSTRACT

Thermal runaway are problems in the operation of lithium-ion batteries. This is due to the high C-rate charge/discharge process in *Li-ion* batteries. This process causes a temperatur rise reaction from internal heat generation during use. Much usable battery energy is lost at high temperaturs due to capacity/power fade, self-discharge, and other things. For safe and efficient operation, *Li-ion* batteries need to be equipped with a battery thermal management system (BTMS) to maintain an optimal temperatur range of 15 – 35 °C and temperatur uniformity of each LIB 0 – 5 °C, thus extending their service life.This study applied the Immersion Cooling method with HFE-7100 working fluid to LFP 18650 type *Li-ion* batteries arranged in a series of 24 cells. The research used a battery Immersion Cooling tester with a 6-channel design. Depth of discharge (DoD) was carried out at 80% of the battery capacity during the discharge process with variations in C-rate 1 C, 1.5 C, 2 C, and 2.5 C and fluid flow rates of 0.5 Lpm, 1 Lpm, and 1 .5 Lpm.

The results showed that the Natural Convection cooling method has surface temperatur characteristics from highest to lowest with the following channel arrangement 6-3-2-4-5-1 compared to the Immersion Cooling and Flow Immersion Cooling methods with flows of 0.5 Lpm, 1 Lpm, and 1.5 Lpm which has surface temperatur characteristics from highest to lowest with the following channel arrangement 6-5-4-3-2-1. The greater the value of the C-rate discharge rate, the greater the surface temperatur of the battery with the Depth of Discharge (DoD) or the exact duration of discharge time. The greater the fluid flow rate value, the smaller the surface temperatur of the battery. At a discharge rate of C-rate 2C with the Flow Immersion Cooling method using HFE-7100 liquid at a flow of 0.5 Lpm, 1 Lpm, and 1.5 Lpm, it has a battery surface temperature of 29.4 ℃, 28.2 ℃, 27.8 ℃, and decreased by 11.4%, 15.1%, and 16.3% respectively compared to the Natural Convection cooling method. The Flow Immersion Cooling method (0.5 Lpm, 1 Lpm, and 1.5 Lpm) has the lowest to highest average local heat transfer coefficient values of 899.8 W/m^2·K, 1154.8 W/m^2·K, and 1315.2 W/m^2·K. The average value of the local heat transfer coefficient at 1 Lpm and 1.5 Lpm has increased by 21% and 46% compared to the fluid flow rate of 0.5 Lpm.

Keywords: Thermal runway, battery thermal management system, Immersion Cooling, HFE-7100, heat transfer coefficient, the average temperatur difference.