UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EXPERIMENTAL STUDY ON THE DEPENDENCY OF THE LITHIUM-ION BATTERY AND TEMPERATURE USING CHI-SQUARE INDEPENDENT TEST

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

……

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ABSTRAK

Ramalan prestasi bateri adalah penting bagi pengurusan sistem bateri, penyelenggaraan bateri, dan reka bentuk berbilang sel pek bateri. Tetapi, kesan suhu masih belum dipertimbangkan dalam kebanyakan model yang sedia ada. Oleh yang demikian, projek ini bertujuan untuk memenuhi kekurangan itu dengan menganalisis kebergantungan bateri lithium-ion dan suhu. Sebuah model bateri telah difabrikasikan untuk menganalisis prestasi bateri dengan pertimbangan kesan suhu. Percubaan prestasi bateri dijalankan. Suhu model yang diubah daripada suhu rendah kepada suhu yang tinggi. Hasil daripada eksperimen model bateri yang dicadangkan itu dikumpul dan dianalisis dengan menggunakan Kaedah Statistik. Kebergantungan bateri lithium-ion dan suhu diuji menggunakan Ujian Chi-square. Pada akhir penyelidikan ini, ianya telah menunjukkan bahawa bateri lithium-ion mempunyai kebergantungan yang tinggi terhadap suhu sekelilingnya.

ABSTRACT

Prediction of battery performance is crucial for management of battery system, maintenance of battery, and designing of multi-cell battery pack. However, the effect of temperature is yet to be considered in most of existing models. In this project, the aim is to compliment on the inadequacy by analysing the dependency of the lithium-ion battery and the temperature. A battery model has been develop in order to analyse the performance of the battery with the considerations of the temperature effect. The experiment of the performance of the battery is carried out. The temperature of the model is varied from low temperature to high temperature. The result of the experiment of the proposed battery model is collected and analysed by using Pearson Correlation Coefficient Method. The dependency of the lithium-ion battery and the temperature is tested using Chi-square Test. At the end of this study, it shows that the lithium-ion battery has a high dependency on the temperature of the surroundings.

DEDICATION

This report is dedicated to my beloved parents who taught and educated me as it enables me to reach at this level.

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I would like to thank my friends and family for their love and supports. With their supports, I am able to finish my research thus completing 50 percent of my bachelor degree. I would like to thank my supervisor, Madam Nor Hafizah Binti Hussin for all the guidance she has given throughout the research. Not to forget, my co-supervisor, Madam Siti Nur Suhaila Binti Mirin who has been a part of this research as my technical advisor when I have a problem with my experiment. Lastly, I would like to thank all of my lecturers for all the knowledge they have passed to me because without it, I might not be able to done my research.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Li-ion	-	Lithium-ion
PTC	-	Passive Temperature Coefficient
Li	-	Lithium
CoO2	-	Cobaltate
NiCd	-	Nickel Cadmium
NiMh	-	Nickel Metal Hydride
V	-	Volt
Ω	-	Ohm
x^2	-	Chi-square
r	-	Correlation Coefficient
ρ	-	rho
DF	-	Degrees of freedom
°C	-	Degree Celcius
°F	-	Degree Fahrenheit
C	-	Coulomb
PPMC	-	Pearson Product Moment Correlation

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter describes about the introduction of this research. The content of this chapter will be the problem statement, objective, scope, research significance and expected outcome of this research as well as the background of the lithium-ion battery.

1.1 Background

Nowadays, Lithium-ion battery has been used to supply energy in almost machines or devices such as cars, tools, personal computers, mobile phones, tablets and so on. Therefore, the prediction of battery performance is crucial for management of battery system, maintenance of battery, and designing of multi-cell battery pack. A various kind of battery models have been suggested and verified to know the behaviours of the battery, such as circuit features and nonlinear capacity features. But, the effect of temperature has yet to be considered in most of existing models.

According to information gained throughout the internet, the surrounding temperature affects the performance of the lithium-ion battery. However, the information has not been proven yet. In this project, the aim is

to compliment on the inadequacy of proofs by analysing the relationship between the temperature effects and the performance of lithium-ion battery.

This project requires a development of a battery model in order to analyse the performance of the battery with the considerations of temperature effect. Comparison between simulation results and experimental results will be made to show that the proposed battery model can accurately predict battery performance under various thermal conditions and the analysis will be done by using a Statistical Method.

1.2 Problem Statement

Lithium ion battery is used in almost all devices. However, it is yet to be considered the effect of temperature on the performance of the lithium ion. Some applications require that the battery is capable of withstanding exposure to high temperatures with less performance loss. Therefore, an analysis on the relationship between the temperature and the performance of a lithium ion battery is going to be done.

1.3 Objectives

The purpose of this project is to study the dependency of lithium-ion battery and the temperature. Hence the objectives of this project are:

1. To design a model to be used for the analysis.
2. To analyse the data obtained from the experiment using Statistical Method.
3. To determine the dependency between the temperature effects and the performance of the lithium-ion battery using chi-square independence test.

1.4 Scope

The aim of this project is to study the dependency of temperature effects and the performance of a lithium-ion battery. In order to archive the objectives of this project, plenty amount of reading needs to be done. Several types of journal articles that are related to the project are collected and read.

After collecting a sufficient amount of information that can be used in the project, the process of planning and designing of the model that will be used to obtain the data is going to take place. The design of the model is going to be simple. A lithium-ion battery will be placed in a box that is attached with temperature control device. The temperature inside the box will be controlled by a computer by connecting the temperature control device with a computer. The lithium-ion battery is connected to a multimeter in order to measure the performance of the battery.

The process of obtaining data is then proceed after the model is ready to be used. The data is observed and recorded several times for each level of temperature to get the accurate result. The data that are going to be taken is the voltage value of the lithium-ion battery, time taken, and the temperature.

After all the data are recorded, the analysis of the correlation between temperature effects and the performance of a lithium-ion battery is going to be done. All the analysis process is done using a statistical method. By using the statistical method, the performance of the lithium-ion battery can be predicted and the effect of temperature can be determined.

When all the processes are finished, the last stage of this study will be to determine the dependency of the temperature effects and performance of a lithium-ion battery which is going to be done using the chi-square independence test.

1.5 Research significance

This research is important because the effects of temperature on the performance of the lithium-ion battery can be determined. By determining the effects, companies can make improvements on the lithium-ion battery to overcome the problems or reduce the heat absorb or dissipated. Users of lithium-ion battery may increase their awareness on how they preserve their batteries.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter describes about the main subject of the project which is the lithium-ion battery. The content of this chapter will be the background, construction, operation, advantages and disadvantages, factor affecting the performance, aging factor, and uses of lithium-ion battery.

2.1 Lithium-ion Battery

Lithium-ion battery has been used as a supply to several devices or machines like mobile phones, personal computers, cars and so on. Lithium-ion battery has a great reputation and has gained popularity throughout the years.

2.1.1 Introduction of Lithium-ion Battery

Pioneer worth of effort with the lithium battery started in 1912 under g. N. Lewis However it might have been not until the initial 1970s when the main non-rechargeable lithium batteries turned into economically accessible (http://batteryuniversity.com/learn/archive/is_lithium_ion_the_ideal_battery).

Lithium may be the lightest of all metals, need the best electrochemical possibility what is more gives the biggest vitality thickness for weight. Endeavors to create rechargeable lithium batteries neglected

because of security issues. Due to the inalienable unsteadiness from claiming lithium metal, particularly throughout charging, examination moved should a non-metallic lithium battery utilizing lithium ions. In spite of the fact that somewhat bring down for vitality thickness over lithium metal, lithium-ion is safe, given sure precautions would met when charging and discharging.

On 1991, the Sony partnership popularized the main lithium-ion battery. Different Producers trailed suit of shield. Those vitality thickness for lithium-ion may be normally Double that of the standard nickel-cadmium. There is possibility for higher vitality densities. Those load qualities are sensibly handy Furthermore carry on Also to nickel-cadmium As far as release. The helter skelter cell voltage for 3.6 volts permits battery packs outlines for special case Mobile. A large portion from claiming today's cell telephones run on a solitary cell. A nickel-based pack might oblige three 1. 2-volt units joined in arrangement. Lithium-ion is a low upkeep battery, favorable element that a large portion other chemistries can't case. There is no memory and no planned cycling is obliged should prolong those battery's an aggregation. Over addition, those self-discharge is less half contrasted with nickel-cadmium, making lithium-ion great suiting to current fuel gage provisions (Levine,2015).

Lithium-ion units make little mischief the point when arranged. Despite its advantages, lithium-ion needs its drawbacks. It is delicate Also obliges a security circlet will look after protected operation. Manufactured under each pack, those insurance circlet breaking points the top voltage of each cell Throughout accuse also keeps the cell voltage starting with dropping excessively low with respect to release. Previously, the mobile temperature may be monitored on keep temperature extremes. The greatest accuse and release current for the greater part packs need aid is restricted to the middle of 1C and 2C. With these precautions on place, the plausibility for metallic lithium plating happening because of cheat will be basically wiped out. Maturing may be a concern for practically lithium-ion batteries and a large number Producers remain quiet around this issue. A percentage ability

crumbling is observable after one year, if those battery may be being used or not. Those batteries habitually fizzle after two or three quite some time. It ought to further bolstering to be noted that different chemistries likewise have age-related degenerative impacts. This is particularly correct to nickel-metal-hydride assuming that uncovered to helter skelter encompassing temperatures.

Toward the same time, lithium-ion packs need aid referred to on have served to five a considerable length of time clinched alongside exactly requisitions. Producers need aid continually enhancing lithium-ion. With such fast progress, it will be challenging on survey how great those reconsidered battery will ageists. Stockpiling to A cool put slows the maturing methodology for lithium-ion (and different chemistries). Producers suggest capacity temperatures of 15°C (59°F). In addition, the battery ought further bolstering be incompletely accused throughout stockpiling. The producer prescribes a 40% accuse. Those the greater part prudent lithium-ion battery As far as cost-to-energy proportion will be the barrel shaped 18650 (size is 18mm x 65. 2mm). This cell will be utilized to portable registering what are more other requisitions that don't interest ultra-thin geometry. On a thin pack may be required, those prismatic lithium-ion Mobile is the best decision. These units originate in a higher expense as far as saved vitality.

2.1.2 Construction of Lithium-ion Battery

Sheet like cathodes and anodes are wound together in a spiral shape. To block micropores and interrupt the reaction of the cell temperature increase excessively for some reason, polymer separator film is wound between the cathodes and anodes. Safety of the cell needs to be assure, for example, the cylindrical battery incorporates a safety mechanism consisting of a circuit breaker, rupture disk, and PTC(possive temperature coefficient)device. The electrolyte is an organic solvent which is stable up to high voltage, in which a lithium salt is dissolved. There are gel polymer

electrolyte between cathodes and anodes in the case of polymer batteries,. Other parts are of very simple constructions. (https://web.archive.org/web/20090411024100/http://www.sony.com.cn/products/ed/battery/download.pdf)

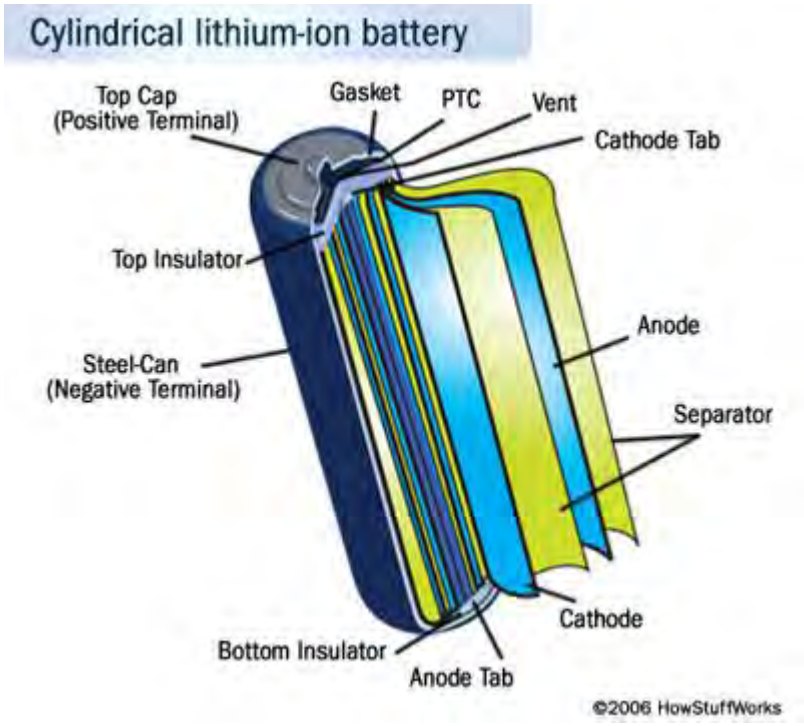

Figure 1.1: Construction of cylindrical lithium-ion battery

(Source:< http://electronics.howstuffworks.com/everyday-tech/lithium-ion-battery1.htm)

2.1.3 Operation of Lithium-ion Battery

When charging, lithium-ion is detached from cathodes consisting of a lithium-containing compound, and the interlayers of carbon in anodes are coated with lithium. Conversely, lithium is detached from between the carbon layers in anodes during discharge, and the compound layers in cathodes are coated with lithium. Reactions occurring in lithium ion rechargeable batteries