CFD ANALYSIS OF HEAT SOURCE FROM ELECTRRIC VEHICLE BATTERY SYSTEM

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This report is submitted in accordance with requirement for the
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SUPERVISOR DECLARATION

"I admit that had read this thesis and in my opinion this thesis was satisfied from the aspect of scope and quality for the purpose to be awarded Bachelor of Mechanical Engineering (Automotive)"

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DECLARATION

"I verify that this report is my own work except for the citation and quotation that the source has been clarified for each one of them"

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Date : 28/6/2013

DEDICATION

To my parents, Yunus Bin Yussof and Sina @Hasinah Bte Alwe, my siblings, my friends and my supervisor, Dr. Noreffendy bin Tamaldin, for supporting me throughout this project and for their understanding in the way I am.

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ABSTRACT

Battery is one of a very important element for electric vehicle. Battery thermal management should be emphasized to ensure the use of extended batteries and to avoid the catastrophic destruction .To identify the behaviour of the heat flow that occur on the battery, analysis of thermal convection flow had been made along the heat sink at batteries . Convection is a mode of heat transfer which includes the movement of the molecules of the material. The fluid motion enhance the heat transfer, since it brings warmer and cooler chunks of fluid into contact, initiating higher rates of conduction at a greater number of sites in a fluid. The application software of Computational Fluid Dynamic (CFD) had been used to show the graphical heat distribution along the flow of air that passes the battery duct. In addition, this study also examines the relationship between vehicle speeds with the rate of heat transfer by using existing data. The result shows the changes of heat for air from inlet to outlet flow for the heat sink batteries. The value of heat transfer is positive means that the heat from the batteries had distributes along the air flow. To find out whether computerized analysis is wrong or not, confirmation had been made by comparing the data with the data from theoretical calculation. Validation results show only slight differences between the data of both analysis and can be assuming that the analysis is valid.

ABSTRAK

Bateri adalah salah satu elemen yang sangat penting untuk kenderaan elektrik. Pengurusan haba bateri perlu diberi penekanan bagi memastikan jangka hayat bateri yang panjang dan untuk mengelakkan kemusnahan yang teruk. Untuk mengenal pasti tingkah laku aliran haba yang berlaku pada bateri, analisis aliran perolakan haba telah dibuat bersama-sama alatan pengurang haba pada bateri. Perolakan adalah mod pemindahan haba melalui pergerakan molekul bahan. Gerakan cecair meningkatkan pemindahan haba, kerana ia membawa ketulan panas dan sejuk cecair kepada sentuhan permukaan , memulakan kadar pengaliran yang lebih tinggi pada nilai yang lebih besar daripada tapak dalam cecair.Perisian "Computational Fluid Dynamic (CFD)" telah digunakan untuk menunjukkan pengagihan haba grafik bersama-sama aliran udara yang melalui salur bateri. Di samping itu, kajian ini juga mengkaji hubungan antara kelajuan kenderaan dengan kadar pemindahan haba dengan menggunakan data yang sedia ada. Hasil menunjukkan bahawa perubahan haba bagi udara dari masukan ke keluaran aliran saluran untuk bateri di kawasan penyejukan haba. Nilai pemindahan haba menunjukkan nilai positif bermaksud haba dari bateri telah dipindahkan pada aliran udara yang melaui kawasan penyejukan haba. Untuk mengetahui samaada analisis berkomputer tersebut berlaku kesilapan atau tidak, pengesahan telah dibuat dengan membandingkan data dengan data daripada pengiraan teori. Keputusan pengesahan menunjukkan hanya sedikit perbezaan antara kedua-dua data analisis dan boleh menganggap bahawa analisis adalah sah.

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LIST OF SYMBOL

SYMBOL

Re	Renault Number
ρ	Density
v	Kinematic viscosity
V	Upstream velocity
Nu	Nusselt Number
h	Heat transfer coefficient
k	Thermal Conductivity
Pr	Pradtl Number
α	Molecular difussivity of heat
Q	Heat transfer
A_s	Surface area
T_s	Temperature surface
T_∞	Ambient temperature
V_{avg}	Average flow velocity
D_h	Hydraulic diameter
f	Smooth tube
T_e	Exit temperature
T_i	Inlet temperature
$\dot{m}$	Mass flow rate

C_p	Specific heat
ΔT_{lm}	Log mean temperature difference

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CHAPTER 1

INTRODUCTION

1.1 Overview

Now a day, the development of electric vehicle is growing rapidly. Many automotive industries explore feasibility study about this kind of vehicle such as Hyundai and Toyota. The electric vehicles getting popular since the awareness of the emission and reduction amount of fuel become the hot issues. There are several factors that need to be considered in producing a good quality of the electric vehicle. Some limitation exists and need to be addressed by the research division in the company. One of importance causes that need to be concern is optimizing the crucial part of electric car that is a battery. Ahmad A.P, (2001), states that the battery performance, life and cost directly affect the performance, life, a cost of the electric vehicle itself. So that is very vital to engineer for identify and do some improvement to the heat management especially in the battery, (Xiao Hu, 2009).

1.2 Objectives

The objective of this project is to characterize the heat transfer behaviour of component in electrical vehicle that is battery system. Besides that, it was intended to study the efficiencies of heat transfer rate in battery parts at different vehicle speed.

1.3 Scopes

The scopes of this project are to study the temperature profile of electric vehicle battery and study about the effect of speed to the efficiencies of heat transfer. Next, is to perform Computational Fluid Dynamic (CFD) analysis and also to provide the recommendation for improvement of cooling system for battery.

1.4 Problem Statement

At UTeM, the existing electric vehicle named as Evergreen had participate the competition of Proton Green Mobility Challenge and this become the starting point for serious development for this kind of vehicle in Faculty of Mechanical Engineering and Faculty of Electrical Engineering. They are lot of factor and analysis that need to be done in order to perform improvement. One of key factor is about the heat management in the vehicle. The heat management system played as a main role to optimize the safety and the durability of the vehicle. In order to identify the problem that may occur in current heat management system, the behaviour of heat transfer for battery needed to be known by doing some analyzation. The result of the analysis will be use to provide recommendation for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrical Vehicle

Electrical vehicle is one of the green technologies where the rotation or movement of the vehicle tyre propelled by the electric motor and powered by electric storage. The integration of electric motor, controller and battery produce the complete main element for the electric vehicle with additional of other transmission and accessories part. Figure 2.1 shows one of the first fully electric vehicles introduces by 'smart for two' in 2009.

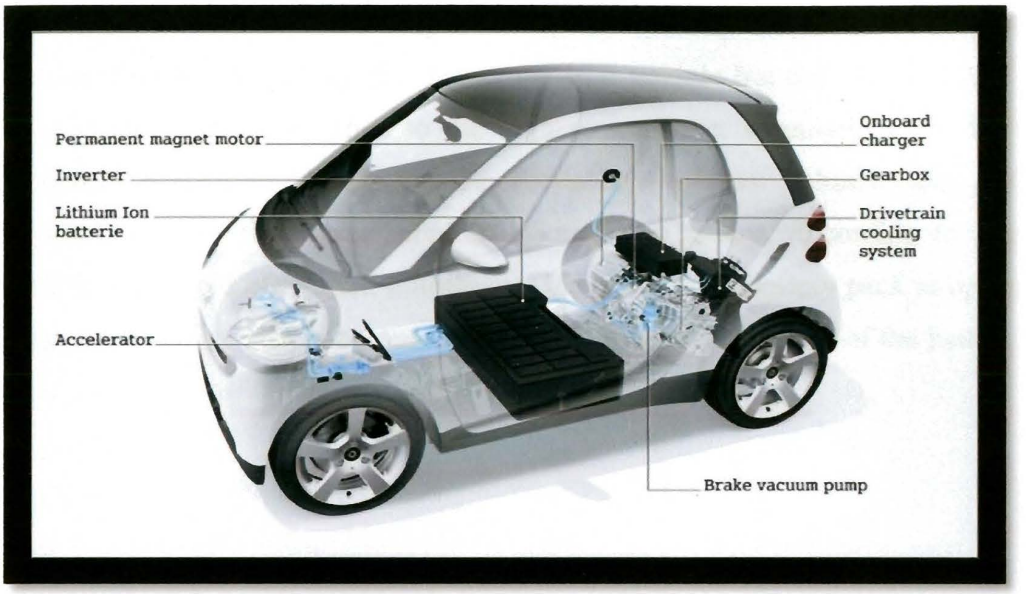

Figure2.1 'smart for two' first fully electrical vehicle (source: http://www.globalgiants.com)

Originally, Sent Leitman, (2008), says the usage of electric motor type vehicle started develop since a long time ago around 1835 that introduced by Thomas Davenport. Until late of the 19th century the development still occurred but the progression process still considered slow. He also state that, by 20th century, the awareness about the emission and the reduction of the fossil fuel become the big issues and lot of car maker and company such as General Motor, Honda, Nissan and Toyota try to implement the electric vehicle in their own production. Since that time, the rapid research and development of electric vehicle occurred to the automotive industry all over the world.

2.1.1 Heat Management System

Heat management system or thermal management for electric vehicle is different with the internal combustion Engine (ICE). In electric vehicle the heat source generated from the electronic devices and the circuit such as the motor electric and the controller differ to the conventional car(internal combustion engine)

the heat source come from the engine during the burning stroke. Usually the heat generation for electric vehicle not hot as the ICE vehicle but the electrical devices and the circuit is very sensitive to the high temperature. Commonly, the thermal management system in electric vehicle focus on the most valuable and critical components that are the power supplier or known as battery. According to Ahmad A.P, (2001), the goal of thermal management is to deliver a battery pack at optimum average temperature. This is because the temperatures effect the life of the battery.

2.2Battery

The purpose of battery is just same as the generator or alternator means that to supplies power but in small portion. The existing of the battery enables human being to use the other portable or small devices such as cell phone, flashlight and calculator. In automotive field, usually the batteries use for the starter and now the usage of battery getting essential as the power supplier for a electrical vehicle. In fabrication of battery involve of anode and cathode as electrode and electrolyte. The type of electrode and electrolyte can be different depends on it purpose .Each unique combination can provide different value of voltage ,Stephen (L.Herman,2011).The Table 2.1shows example of electrolyte and electrode combination and the volt result while the Figure 2.2 shows the common structure of battery.

Table 2.1 Combination of Electrode and Electrolyte and the Volt result electrode (source from (Stephen L.Herman, 2011))

CELL	NEGATIVE PLATE	POSITIVE PLATE	ELECTROLYTE	VOLTS PER CELL
Primary Cell				
Carbon-zinc (Leclanche)	Zinc	Carbon, manganese dioxide	Ammonium chloride	1.5
Alkaline	Zinc	Manganese dioxide	Potassium hydroxide	1.5

Mercury	Zinc	Mercuric oxide	Potassium hydroxide	1.35
Silver-zinc	Zinc	Silver Oxide	Potassium hydroxide	1.6
Zinc-air	Zinc	Oxygen	Potassium hydroxide	1.4
Edison-Lalande	Zinc	Copper oxide	Sodium hydroxide	0.8
Secondary Cells				
Lead-acid	Lead	Lead dioxide	Dilute sulphuric acid	2.2
Nickel-iron (Edison)	Iron	Nickel oxide	Potassium hydroxide	1.4
Nickel-cadmium	Cadmium	Nickel hydroxide	Potassium hydroxide	1.2
Silver-zinc	Zinc	Silver oxide	Potassium hydroxide	1.5
Silver-cadmium	Cadmium	Silver oxide	Potassium hydroxide	1.1

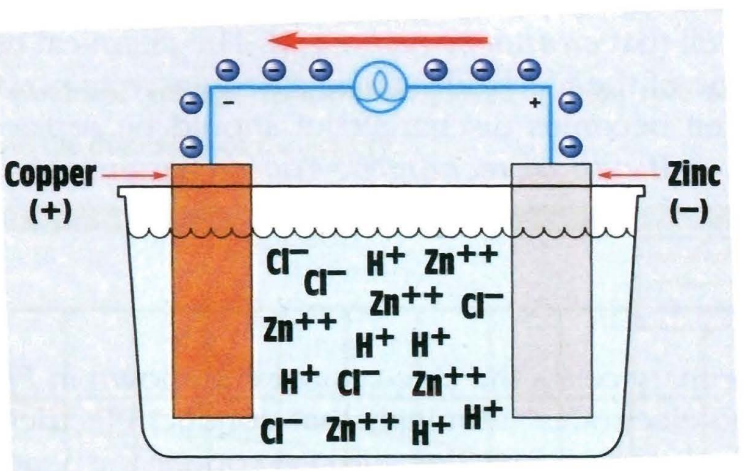

Figure 2.2 Electrode flow from the zinc to cooper electrode (source from (Stephen L.Herman, 2011))

2.2.1 Lithium-ion Battery

Lithium-ion cells a very popular for portable equipment such as net book, video camera, cell phone. This cell is choosing due to the capability of the cell to recharge and offer very high energy density for their size and weight. They exhibit a voltage of 3.6 volts per cell, which is the same voltage that can be obtained by connecting three nickel-cadmium or three nickel metal hydride cells in series. Under

proper charging condition these cell can be recharge about 500 times. Moreover, this cell also has no problem with memory accumulation means that they can be recharged to their full capacity each time they charged (Stephen L.Herman, 2011). Other than that this cell also can safely be recharged because they do not contain metallic Lithium.

2.2.2 Battery Efficiency

In the electrical vehicle, temperature played a main role to giving batter performance and the durability of the battery.

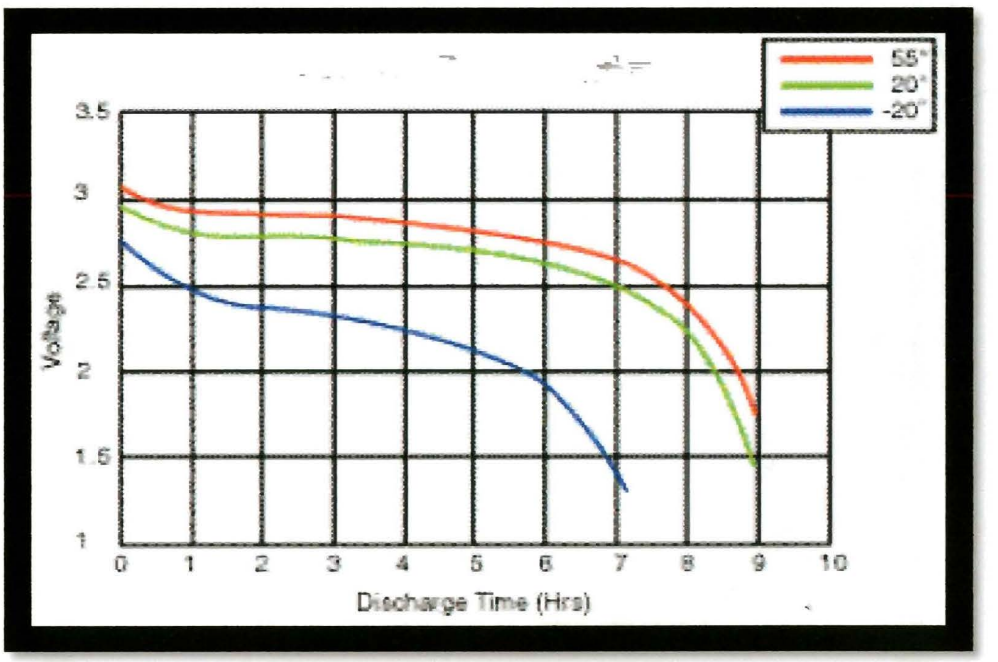

Figure 2.3: Performance discharge of the volts with different temperature (source from (S.Al-Hallaj, 2004)

Figure 2.3 shows how the temperatures effect the performance of voltage discharge. At the lower temperature shows the electrolyte itself may freeze and as a result Lithium plating on the anode causing a permanent reduction capacity. At the higher temperature chemical may break as a result the battery broke. So it is very