PERFORMANCE OF PR(,LENGE ELECTRIC
CAR

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ABSTRACT

This project report deals with performance of electric vehicle Proton Green Mobility Challenge (PGMC) 2012 which won first place in best acceleration and make UMP proud of it. The performance of this proton saga converted to electric needs to be evaluated. The performance test is done on chassis dynamometer which is in the lab at University Malaysia Pahang (UMP). The objective of this project is to determine the performance of electric car with respect to power, torque and voltage drop of the battery while using it. The method that was conducted during the performance test is two tests which are performance curve test and acceleration test. Both tests are done into two modes which is economy and power mode. From result, the economy mode is a power saving mode which produce low power, low torque and low voltage consumption meanwhile the power mode is for high performance mode. In power mode, the car produces high torque, power and consumes a lot of voltage. The performance is done for first, second and third gear. As a conclusion the performance of first gear economy mode has reach maximum power is 21.82 kW and maximum torque of 103 Nm. The performance for the second gear economy mode has reached maximum power of 22.89 kW and the maximum torque is 56 Nm. The performance of third gear economy mode has reached maximum power of 24.71 kW and maximum torque is 30 Nm. The performance of first gear power mode has reach maximum power is 37.8 kW and maximum torque of 198 Nm. The performance for the second gear economy mode has reached maximum power of 40.1 kW and the maximum torque is 130 Nm. The performance of third gear economy mode has reached maximum power of 40.5 kW and maximum torque is 51 Nm. The main criterion that changes the mode of the car is the need for the torque and power. In the acceleration test, economy mode reaches a distance of quarter mile in 31.8 second while in power mode, it took 28 seconds.

ABSTRAK

Laporan projek mengatakan prestasi kenderaan elektrik Proton Green Mobility Challenge (PGMC) 2012 yang telah memenangi tempat pertama dalam pecutan yang terbaik dan membuat UMP bangga dengan itu. Prestasi saga proton ini yang ditukar daripada kenderaan biasa kepada kenderaan elektrik untuk dinilai. Ujian prestasi dilakukan pada casis dinamometer yang berada di dalam makmal di Universiti Malaysia Pahang (UMP). Objektif projek ini adalah untuk menentukan prestasi kereta elektrik berkenaan dengan kuasa, tork dan kejatuhan voltan bateri ketika penggunaannya. Kaedah yang dijalankan semasa ujian prestasi adalah dua ujian yang pencapaian ujian keluk dan ujian pecutan. Kedua-dua ujian yang dilakukan ke dalam dua mod iaitu mod ekonomi dan kuasa. Dari hasil, mod ekonomi mod penjimatan kuasa yang menghasilkan kuasa yang rendah, tork rendah dan penggunaan voltan rendah pula mod kuasa adalah untuk mod berprestasi tinggi. Dalam mod kuasa, kereta menghasilkan tork yang tinggi, kuasa dan menggunakan banyak voltan. Prestasi dilakukan untuk gear pertama, kedua dan ketiga. Kesimpulannya prestasi mod ekonomi gear pertama telah mencapai kuasa maksimum adalah 21.82 kW dan tork maksimum 103 Nm. Prestasi untuk mod ekonomi gear kedua telah mencapai kuasa maksimum 22.89 kW dan tork maksimum ialah 56 Nm. Prestasi mod ekonomi gear ketiga telah mencapai kuasa maksimum 24.71 kW dan tork maksimum ialah 30 Nm. Prestasi mod kuasa gear pertama telah mencapai kuasa maksimum ialah 37.8 kW dan tork maksimum 198 Nm. Prestasi untuk mod ekonomi gear kedua telah mencapai kuasa maksimum 40.1 kW dan tork maksimum 130 Nm. Prestasi mod ekonomi gear ketiga telah mencapai kuasa maksimum 40.5 kW dan tork maksimum 51 Nm. Kriteria utama yang mengubah cara kereta itu adalah keperluan untuk tork dan kuasa. Dalam ujian pecutan, mod ekonomi mencapai jarak suku batu di 31.8 kedua semasa dalam mod kuasa, ia mengambil masa 28 saat.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The burgeoning electric vehicle (EV) industry cannot be understood by simply looking at cars. Indeed, in the last year, only the electric car sector of EVs has lost a year due to the Japanese tsunami and badly delayed model launches and it has been particularly sensitive to troubled economies as well. A plug in car is meaning, the vehicle will be used is the morning and at night the car will be charge 100% so that it can be used the next day.

In this modern era, every person in this world using a vehicle such as car, motorcycle and heavy vehicles in order to reach their desired destination. Some people uses own transport or some uses public transportation. Besides that, most of the company uses heavy vehicles to send their products to customers. Nowadays, the amount of car that uses in the world is uncountable. So, the best car will be electric car. An electric car uses a motor to run the car. According to Clive.M. 2010 the advantages of having a plug-in car are,

1) Electric cars improve the security of vehicle energy supply using motor
2) Electric car offers much improved air quality in cities, and
3) Electric car offers drastically reduced traffic noise.

Every year, there will be a race in between automotive industry in Malaysia such as Perodua Eco Challenge. Recently, Protón Malaysia Sdn. Bhd. and Agensi Inovasi

Malaysia (AIM) had a race by the name Proton Green Mobility Challenge (PGMC), 2012 and held in Sepang International Circuit whereby all the university in Malaysia took part in the challenge. University of Malaysia Pahang (UMP) modified a proton persona car which is called UMP-EV. Eventually, (UMP-EV) team made the university proud when its car emerged as the electric car with the best acceleration. Although the team only secured a second place spot and, its vehicle won the coveted "Quarter Mile Acceleration" prize which comes with a RM5,000 reward with achieving at maximum voltage it produces 116 kilometer per hour around 19-21 second. The battery types UMP-EV is lithium ion with 13 modules of 2P-2S cell whereby produces 96V, 86 Ampere-hour and 8.45 kWh is. Besides that, the design for discharge is discharge one module to get better SOC estimation and to test balancing.

Figure 1.1: PGMC-EV picture.

Besides that, the performance testing of UMP-EV is done on chassis dynamometer. Chassis dynamometer is widely used in all automotive manufacturing company. Besides that, a dynamometer is function as a load to determine the power and torque output (Dr. Horizon.G.,2005, Jirapat.J & Saiprasit.K,2012). Chassis dynamometer is one of the most top equipment used to run some quick tests for installed power and determine the structure of chassis and drive train according to (Harold.B 2010). A chassis dynamometer can troubleshoot a vehicles problem quickly and easy for technician to repair. Chassis dynamometer has its own style and design. The minimum characteristic that should be in chassis dynamometer is either 4 rollers or 8 rollers for 2 wheel and 4 wheels car respectively. Furthermore, there are several types of dynamometer such as break dynamometer, dry friction break dynamometer, hydraulic brake dynamometer and eddy current dynamometer according to (Dr. Horizon.G,2005).

1.2 PROBLEM STATEMENT OF THE PROJECT

The battery storage cannot last long because of voltage discharge is very high. Besides that, the charging of battery take long time and have to look for new charging mechanism.

1.3 OBJECTIVE OF THE PROJECT

Determine the performance of Electrical Car with respect to power, torque and voltage of the battery storage using chassis dynamometer testing.

1.4 SCOPE OF THE PROJECT:

This project focuses on following points:

1) Cover the Electric Car (EV) from Proton Green Mobility Challenge, 2012, which design by UMP
2) The battery storage system design by PGMC group 2012
3) The system of discharge design by the PGMC group 2012.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Why do human beings need to use electric vehicle (EV) cars? EV is a new design in recent years and it is function like a car but it would use plug-in charger instead of fuel gasoline or fuel according to (Clive.M,2010). This is because the electric car has a better efficiency than gasoline engine although the manufacturing of electric car is expensive. Besides that, every activity that human doing like shopping, going to work or even seeing a doctor need a car. EV holds the potential of transforming the way the world moves according to (EV City Casebook).

EV cars play a big role in environment. Environment is very important for human being because of environment human getting fresh air. If the environment is polluted, the amount of human will be reduced year by year. As a result, there will be no living things in any environment anymore. So, environment must be safe. In order to save the environment, there must not have any pollution such as air, noise or water pollution. Car usage is getting more day by day and time by time because everyone has their own thing to do. Car is design to go from one place to another. Besides that, cars can cause air and noise pollution at the traffic, the air pollution is because of emission from the car and noise pollution is because of the horn and even the engine.

EVs can increase energy security by diversifying the fuel mix and decrease dependence on petroleum, while reducing emissions of greenhouse gases and other pollutants. EV is also introduced to reduce in usage of fuel or gasoline. This is because, nowadays almost every person dependent on fuel. Dependence on oil makes the overall economy and household budgets highly vulnerable to volatile oil prices according to (Don.A & Amine.M,2012). The International Energy Agency (IEA) believes that oil will peak between "2013 and 2037" and the oil milling must reserve the oil for upcoming years. So it is better to use EV car and people can have a budgeted life. Furthermore, for every activity it needs to pour oil. This is also an advantage for human because nowadays market price for oil is higher. Purchasing a car, it must have the best fuel consumption, lowest emission and that particular vehicle must fit to a person budget. So, EV car has a better efficiency than gasoline car. Moreover, EV car uses batteries to run the car. As a result, human being does not have to pump in oil and can save the money.

2.2 MAIN SYSTEM IN EV

EV cars have their own system but the major parts are the same which will complete the construction of the car. The major components are

1) Battery Management System
2) Motor Control
3) Thermal Control
4) Performance

2.2.1 Battery Management System (BMS)

2.2.1.1 Introduction

Batteries Management System (BMS) means different things to different people. To some it is simply Battery Monitoring, keeping a check on the key operational parameters during charging and discharging such as voltages and currents and the battery internal and ambient temperature. The monitoring circuits would normally provide inputs to protection devices which would generate alarms or disconnect the battery from the load or charger should any of the parameters become out of limits. For the power or plant engineer responsible for standby power whose battery is the last line of defense against a power blackout or a telecommunications network outage? Such systems encompass not only the monitoring and protection of the battery but also methods for keeping it ready to deliver full power when called upon and methods for prolonging its life. This includes everything from controlling the charging regime to planned maintenance. For the automotive engineer the Battery Management System is a component of a much more complex fast acting Energy Management System and must interface with other on board systems such as engine management, climate controls, communications, and safety systems. There are thus many varieties of BMS.

2.2.1.2 Designing a BMS

In order to control battery performance and safety it is necessary to understand what needs to be controlled and why it needs controlling. This requires an in depth understanding of the fundamental cell chemistries, performance characteristics and battery failure modes particularly Lithium battery failures. The battery cannot simply be treated as a black box.

2.2.1.3 BMS Building Blocks

There are three main objectives common to all Battery Management Systems are for

1) Protect the cells or the battery from damage
2) Prolong the life of the battery
3) Maintain the battery in a state in which it can fulfill the functional requirements of the application for which it was specified

To achieve these objectives the BMS may incorporate one or more of the following functions.

1) Cell Protection, protecting the battery from out of tolerance operating conditions is fundamental to all BMS applications. In practice the BMS must provide full cell protection to cover almost any eventuality. Operating a battery outside of its specified design limits will inevitably lead to failure of the battery. Apart from the inconvenience, the cost of replacing the battery can be prohibitive. This is particularly true for high voltage and high power automotive batteries which must operate in hostile environments and which at the same time are subject to abuse by the user.
2) Charge control, this is an essential feature of BMS. More batteries are damaged by inappropriate charging than by any other cause.
3) Demand Management While not directly related to the operation of the battery itself, demand management refers to the application in which the battery is used. Its objective is to minimize the current drain on the battery by designing power saving techniques into the applications circuitry and thus prolong the time between battery charges.
4) SOC Determination, many applications require knowledge of the State of Charge (SOC) of the battery or of the individual cells in the battery chain. This may simply be for providing the user with an indication of the capacity left in the battery, or it could be needed in a control circuit to ensure optimum control of the charging process.
5) SOH Determination, the State of Health (SOH) is a measure of a battery's capability to deliver its specified output. This is vital for assessing the readiness

of emergency power equipment and is an indicator of whether maintenance actions are needed

6) Cell Balancing In multi-cell battery chains small differences between cells due to production tolerances or operating conditions tend to be magnified with each charge / discharge cycle. Weaker cells become overstressed during charging causing them to become even weaker, until they eventually fail causing premature failure of the battery. Cell balancing is a way of compensating for weaker cells by equalizing the charge on all the cells in the chain and thus extending battery life

7) History - (Log Book Function) Monitoring and storing the battery's history is another possible function of the BMS. This is needed in order to estimate the State of Health of the battery, but also to determine whether it has been subject to abuse. Parameters such as number of cycles, maximum and minimum voltages and temperatures and maximum charging and discharging currents can be recorded for subsequent evaluation. This can be an important tool in assessing warranty claims

8) Authentication and Identification The BMS also allows the possibility to record information about the cell such as the manufacturer's type designation and the cell chemistry which can facilitate automatic testing and the batch or serial number and the date of manufacture which enables traceability in case of cell failures

9) Communications, most BMS systems incorporate some form of communications between the battery and the charger or test equipment. Some have links to other systems interfacing with the battery for monitoring its condition or its history. Communications interfaces are also needed to allow the user access to the battery for modifying the BMS control parameters or for diagnostics and test.

2.2.1.4 Types of BMS

BMS consist of various types because each EV car got certain specification. Hence, there BMS production will be various such as

1) Orian BMS
2) Lithiumate Pro BMS

2.2.1.4.1 Orian BMS

The Orion BMS implements an extensive list of features designed to protect the battery pack. These features include:

a) State of charge calculations.
b) Cell over-voltage and under-voltage protection.
c) Intelligent battery balancing (passive).
d) Battery charger control.
e) Pack temperature monitoring.
f) Monitors health of battery pack.

Cells are protected from over-voltage, under-voltage, over-current, over-temperature, and under-temperature based on the programmed minimum and maximum values in the battery profile. Intelligent, efficient cell by cell balancing is provided to maximize the usable range of the battery. The BMS also monitors the health of both individual cells and the total pack and will trigger error trouble codes if either the pack or individual cells are in poor health.

2.2.1.4.2 Lithiumate Pro BMS

This BMS monitors, evaluates, balances and protects a Li-Ion battery pack. Its main function as below.

1. Off the shelf, plug-and-play

2. For professional applications: commercial grade, metal case (not sealed)
3. Distributed (a cell board is mounted on each cell: measures voltage and temperature, balances the cell)
4. Minimum number of wires in HV pack, single wire to adjacent cell boards
5. For large packs: up to 256 cells (~ 900 V), in up to 16 banks
6. Supports all cell form factors: prismatic, small & large cylindrical, pouch
7. Supports mid-voltage Lithium-ion chemistries:
    a) Lithium iron phosphate (LFP): LiFePO4 , LiFeYPO4
    b) $LiCoO_2$ (LCO) - Lithium cobalt oxide
    c) $LiMn_2O_4$ (LMO) - Lithium manganese oxide
    d) $LiNiMnCoO_2$ (NMC) - Lithium nickel manganese cobalt oxide
    e) $LiNiCoAlO_2$ (NCA) - Lithium nickel cobalt aluminium oxide
8. Protects cells from over current, under/over voltage, under/over temperature
9. Dissipative (passive) balancing (top balance)
10. Sophisticated, digital technology: reports each cell's voltage and temperature
11. CAN and RS232 communications
12. Fully configurable, field programmable
13. Cable mount Hall Effect current sensor
14. Contactor drivers with precharge
15. Pack isolation loss detection (optional)
16. Compatible with these chargers
17. Compatible with these motor drivers
18. Graphics User Interface

2.2.1.5 Comparison of BMS

Table 2.1: Comparison between Two BMS

	Orian BMS	Lithiumate Pro
Overcharge/discharge, thermal & overcurrent protechtion	✓	✓
Cell & Pack Health Monitaring	✓	✓
Cell Balancing	✓	✓
Field Programmable	✓	✓
State of Charge Monitoring	✓	✓
Charge/Discharge Current Limits	✓	✓
Cell & Pack Internal Resistance	✓	✓
Trouble Codes / OBD-II Freeze Frame	✓	x
Programmable OBD-II support	✓	x
Centralized Design	✓	x
CANBUS Interfaces	2 Interfaces	1 Interfaces
Isolation Fault Detection	✓	Optional
Automotive Grade Locking Connectors	✓	x
Easy to Disconnect from Battery	✓	x
Cell Voltage Sampling Range	30 mS	600 –10000 mS
Cell Voltage Measuring Range	0.5 – 5.0 V	2.04 – 4.54 V

Source: http://www.orionbms.com/comparison/

2.2.2 Motor Control

The EV motor control regulates the motor's speed and limits the motor's maximum current level according to (R.Valentine, 1993). The motor speed range can vary from zero to wide open throttle (WOT), which requires the controller's power transistors to sustain high peak currents and provide good efficiency at nominal cruise speeds. The controller also has to be self-protecting against electrical disturbances such as an intermittent battery cable or a faulty throttle position sensor. The traction motor category determines the type and cost range of the controller. Pulse width modulation (PWM) type controllers are often used with brush type DC motors which have been successfully applied for many years in fork-lift and electric vehicles conversion. Basically motor control is design which has performance and economy mode.

Performance mode is motor at highest torque. At the beginning, usually motor will have highest torque. In order to get performance mode, the EV car should have test. Besides that, the main criteria for performance mode are maximum power. Usually EV car produce lesser power compare to gasoline engine according to (Jack.E,). Economy mode is totally reverse from performance mode. This is because economy mode do not need highest speed but it need to test the longest distance that can travel. Usually EV car have lesser distance compare to gasoline engine. Each EV car has its own performance and economy mode.

2.2.3 Thermal Control

2.2.3.1 Thermal Control on Battery Temperature

Battery performance, life, and cost directly affect the performance, life, and cost of the electric vehicles (EVs). Battery temperature influences the availability of discharge power (for start up and acceleration), energy, and charge acceptance during energy recovery from regenerative braking. These affect vehicle drive-ability and fuel economy. Temperature also affects the life of the battery. Therefore, ideally, batteries should operate within a temperature range that is optimum for performance and life. The desired operating temperature range is different for different battery types (with different electrochemistry). Usually, the optimum temperature range for the battery operation (desired by the battery manufacturer) is much narrower than the specified operating range for the vehicle (identified by the vehicle manufacturer). For example, the desired operating temperature for a lead acid battery is 25°C to 45°C, however the specified vehicle operating range could be -30°C to 60°C. In addition to considering the (absolute) temperature of a battery pack, uneven temperature distribution in a pack should be also considered.

Temperature variation from module to module in a pack could lead to different charge/discharge behavior for each module. This, in turn, could lead to electrically unbalanced modules/packs, and reduced pack performance. For high temperature batteries such as ZEBRA and lithium metal polymer batteries, thermal management is considered an integral part of the battery pack and has been included in the design by the battery manufacturers. The need for battery thermal management for ambient temperature batteries such as valve regulated lead acid (VRLA), nickel metal hydride (NiMH), and lithium ion (Li-Ion) was not obvious initially, however, EV battery and vehicle manufacturers have come to realize such a need. Current prototype or production EVs with ambient temperature batteries has battery thermal management systems - some more elaborate than others.

To evaluate battery pack designs and provide solutions for battery thermal issues, we have used heat transfer and fluid flow principles, finite element thermal analysis, and heat transfer and fluid flow experiments. We have used thermal imaging techniques and battery calorimetric to measure thermal characteristics of modules and cells in support of battery pack thermal evaluation and design. The goal of a thermal management system is to deliver a battery pack at an optimum average temperature with even temperature distribution as identified by the battery manufacturer. However, the pack thermal management system has to meet the requirements of the vehicle as specified by the vehicle manufactured and it must be compact, lightweight, low cost, easily packaged, and compatible with location in the vehicle.

In addition, it must be reliable, and easily accessible for maintenance. It must also use low parasitic power, allow the pack to operate under a wide range of climate conditions (very cold to very hot), and provide ventilation if the battery generates potentially hazardous gases. A thermal management system may use air for heat/cooling/ventilation, liquid for cooling/heating, insulation, thermal storage such as phase change materials, or a combination of these methods. The thermal management system may be passive or active. The thermal management control strategy is done through the battery electronic control unit according to (Ahmad.A.P,2001).

2.2.3.2 Thermal Control on Motor Temperature

Permanent magnet motors are typically used in many humanoid robots. Causes of this kind of motor's failure are grouped into next three.

1) Burnout of winding wire in the motor core by overheat.
2) Degauss of a magnet by overheat.
3) Damage to mechanical elements, i.e., bearings or a shaft

In the cases of motors with brush, damage to the brush is also considerable. In this paper, we discuss about only brushless motors. Within the three causes, the most problematic case in the humanoid robot is the burnout of winding wires, since humanoids require high motor torque or joint angle velocity in a very short time. It is caused as the result of the motor core's over temperature by over current to the motor. Manufacturers of motors guarantee absolute maximum operation temperatures. We can avoid the motor burnout by controlling the temperature of the absolute maximum range or less. To avoid motor burnout, two traditional methods are widely used. One is the method to keep motor current below a certain limitation. Another is to maintain temperature of motor housing below a limitation. In order to discuss about these methods, we use a simple thermal model of motors, two-resistor model.

The detail of the model is described in later section. First, to evaluate thermal characteristics in short-term operation, maximum currents which can be applied without the core temperature exceeding the absolute maximum temperature in certain time