ELECTRIC MOTOR PROPULSION SYSTEM FOR ELECTRIC VEHICLES (EV)

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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I hereby declare that the work in this report is my own research except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

In a bid to perform electric vehicle modeling in terms of propulsion system of the electric motor, the calculation and the analysis of vehicles dynamics have been done. Its will concluded the suitable motor that will used to move the specific vehicles, ISWARA. Through the literature review, this thesis presented the introduction of electric vehicles and the major components of its system. Besides that, it will discuss the propulsion system for electric motor of the electric vehicles. Next, calculation and analysis been done to find the requirement power and force to move the vehicle in fixed velocity. Results get from the calculation will be used to find the characteristics of electric motor and finally the suitable electric motor are selected. Simulation done to analysis the suitable motor either it can perform and give the similar results compare to calculation made before or not. At the end of this thesis, conclusion is made due to the results get from the simulation analysis. Recommendation in improving the results from whole of the project will also be discuss.

ABSTRAK

Dalam langkah menghasilkan model kenderaan elektrik yang terdiri daripada pembahagian sistem dalam motor eletrik, pengiraan dan analisa berkaitan dengan dinamik kenderaan harus dibuat. Ia akan member jawapan kepada motor yang sangat sesuai digunakan untuk menggerakan kenderaan yang telah ditetapkan iaitu ISWARA. Melalui gambaran penulisan, kajian akan memperjelaskan tentang pengenalan untuk kenderaan elektrik dan komponen-komponen penting dalam system kenderaan tersebut. Selain itu, ia akan membincangkan pembahagian system untuk motor elektrik dalam kenderaan elektrik. Selanjutnya, pengiraan dan analisa akan dilakukan untuk mencari keperluan kuasa dan tenaga bagi menggerakkan kenderaan dalam kelajuan yang ditetapkan. Hasil daripada pengiraan akan digunakan untuk mencari ciri-ciri tertentu elektrik motor dan akhirnya elektrik motor yang sesuai akan dipilih. Simulasi dilakukan untuk menganalisa adakah elektrik motor yang sesuai itu akan menjalankan dan memberikan keputusan yang serupa dengan hasil pengiraan yang dilakukan sebelum ini atau tidak. Diakhir kajian ini, keputusan akan dibuat berdasarkan hasil yang diperolehi daripada simulasi analisa. Cadangan untuk mebaikpulih hasil keputusan daripada keseluruhan projek akan dibincangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

EV	-	Electric vehicle
HEV	-	Hybrid-electric vehicle
BEV	-	Battery-electric vehicle
FCEV	-	Fuel cell-electric vehicle
SB	-	Supercapacitor bank
PWM	-	Pulse-width modullation
T	-	Torque
F	-	Force
	-	Tractive force
	-	Aerodynamic drag
	-	Rolling resistance force
	-	Gravitational force
	-	Force gives linear acceleration
	-	Force gives angular acceleration to rotating motor

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Todays, as a human being transportation become an important role for getting a comfortable life. But, human not realize that next 50 years, global population will increase from 6 billion to 10 million and in order aspects, the number of vehicles will increase from 700 million to 2.5 billion. If all these vehicles are propelled or get their sources energy by internal combustion engines (ICEs), then where will the oil come from? Where should the emission be disseminated? Would the sky be permanently blue? The gloomy answer to these hard questions compel human to strive for sustainable road transportation for 21st century [4].

Electric Vehicles (EV) is the vehicles that implemented the energy gain from the propulsion electric source which can also be delivered by an electric machine. It definitely emphasizes the benefits of electro-mechanical solutions. Nowadays, in automotive industry the find that EV is the most suitable being on the road because it is friendly environment and can reduce the pollution according to reducing the application of fuel or petrol. Beside that, EV is an extraordinary and different from other road vehicles. It involve with electric propulsion and give a variation technology in order to save the world for pollution. EV are include with battery electric vehicles (BEVs), hybrid-elctric vehicles (HEVs), and fuel-cell electric vehicles (FCEVs) [5]. The idea of EV can be described as a multidisciplinary subject which covers broad and complex aspects. The core of this advance technologies are consist of chasis and body

technology, propulsion technology, and energy source technology. That why it become a tough task to write a thesis based on this multidisciplinary and advance studies.

Development of BEVs, HEVs and FCEVs are forwards and get very well attention from this wide world. But compare to this deviation of EV they give different stages of development, different problem that appears, and different strategy to solve the problem. In BEVs, the main problem is about it batteries. BEVs system suitable for small EV because it just give a short range and can be used for low-speed community transportation. For HEVs, it become and reach a consumers need but the major challenge is about the cost. Besides that, for FCEVs technology, it seem to give long-term potential for future mainstream vehicles but its technology are little bit new and still early development stage and major problem that going to be faced was about it cost and refueling system.

One of the well known type of EV is HEV or hybrid electric vehicles. A hybrid electric vehicle (HEV) is a vehicle that used two or more distinct power sources to propel the vehicle such as an on-board rechargeable energy storage system (RESS) and a fueled power source (internal combustion engine or fuel cell) for vehicle propulsion, air and internal combustion engines. It is also called a bi-energy vehicle, human powered bicycle with electric motor or gas engine assist, or a human-powered or sail boat with electric power. The term most commonly refers to Hybrid-electric vehicle (HEV) which includes internal combustion engines and electric motors (generally powered by electric batteries or other rechargeable energy storage system -RESS-).

The idea of hybrid vehicles is not a recent development, early 1960s, several companies attempted to develop bipolar lead (acid batteries) for hybrid-electric vehicles [J.L. Arias, J.J. Rowlett, E.D. Drake, Journal of Power Sources, 40 (1993) 63–73.]. Hybrid vehicles have the potential to increase fuel economy by using a primary engine operating at a constant power to supply average power requirements and a surge

power unit for peak power demands and to recover braking energy. But until now, there have no detailed system optimization analysis has been performed for hybrid electric vehicles [8].

Transportation becomes the major contributor to multiple global environmental problems such as greenhouse effect-gas emissions and urban pollution. The hybrid vehicle typically achieves greater fuel economy and lower emissions than conventional internal combustion engine vehicles (ICEVs), in terms of fewer emissions being generated. These savings are primarily achieved by four elements of a typical hybrid design. First, recapturing energy normally wasted during braking. Second, having significant battery storage capacity to store and reuse recaptured energy. Third, shutting down the gasoline or diesel engine during traffic stops or while coasting or other idle periods and last one is relying on both the gasoline (or diesel engine) and the electric motors for peak power needs resulting in a smaller gasoline or diesel engine sized more for average usage rather than peak power usage.

These features make a hybrid vehicle particularly efficient for city traffic where there are frequent stops, coasting and idling periods. In addition noise emissions are reduced, particularly at idling and low operating speeds, in comparison to conventional gasoline or diesel powered engine vehicles. For continuous high speed highway use these features are much less useful in reducing emissions. Vehicles which have significant idle periods and only occasional needs of peak power like railroad switching locomotives or repeated lifting and lowering cycles like Rubber Tyred Gantrys are also good candidates for hybrid systems resulting in potentially significant fuel and emission savings.

1.2 PROJECT BACKGROUND

These studies are coming to analyze the characteristics of the vehicles which is PROTON ISWARA. By pick up one parameter of velocity, a lot of vehicles dynamics calculation will be consider in finding a required power to move it. After that, this project will describe type of electric motor and used the required power for moving the ISWARA (which define by calculation before) to choose one suitable electric motor. Finally, the application of the results from the calculation to propose the most suitable motor driver either from AC motor or DC motor, will be proven by done a simulation of the vehicles drivetrain system. Then this project summarize either the recommended electric motor is suitable or not and describe any error on finding the required power for moving ISWARA as a vehicle.

1.3 PROJECT OBJECTIVE

To build one system in determine the power and force required to move the vehicles (power demand).

To choose a most suitable motor considering from the power and force requirement system (algorithm) done in objective one.

1.4 PROJECT SCOPE

Scope is the way how to define problem by putting a wall around it. Scopes for this thesis are supposedly being:

1) This thesis is about Electric Vehicles (EV) and learning about EV. But major studies done for motor in EV
2) Characteristics (physical) of the vehicle that been considering in choosing a suitable motor for fixed vehicles which is PROTON ISWARA.

3) Find the demand power and force requirement to move the vehicle (PROTON ISWARA) based on calculation in vehicles dynamics.
4) Using the force requirement and demand power that been calculated, propose a suitable motor for this vehicle.
5) Done a simulation and analysis to prove propose motor can running the vehicle.

1.5 SOURCE OF KNOWLEDGE

Adaptation of the knowledge that been used in supporting the thesis are exactly get from some sources that consider very truth and valuable. Source that been used are from:

1) Science direct articles regarding to the method of controlling
2) PROTON Sdn. Bhd., in terms of vehicles specification of ISWARA
3) IEEE INDUSTRY APPLICATION MAGAZINE regarding information to choose the motor
4) Previous thesis based on motor, EV and vehicles dynamics:
    - PHD thesis
    - MASTER thesis
    - Inventors technical report
    - Books
    - journal

1.6 THESIS OUTLINE

CHAPTER 1 is about the explanation and introduction for Electric Vehicle (EV) and the purpose of this thesis written to give an explanation about the title of the project which is “Electric Motor Propulsion System For Electric Vehicle”.

CHAPTER 2 represented the idea of propulsion system in electric vehicles which consists of the vehicles modeling, electric motor characteristics, calculation in vehicles dynamics and vehicles specification that will consider off.

CHAPTER 3 described the methods that are used to determine power and torque required to move the ISWARA in desired velocity. This chapter also explained the comparison in vehicles dynamic characteristics

CHAPTER 4 explained about the other methods to prove the calculation been made are valid which is SIMULATION method. This chapter come out with the results from the propose electric motor that will get from the chapter 3 before and this chapter will estimated either that will be the most suitable electric motor or not.

CHAPTER 5 presents the summary and conclusions due to the final results of this project.

CHAPTER 2

LITERATURE REVIEW

2.0 PROPULSION SYSTEM FOR ELECTRIC VEHICLE

2.1 ELECTRIC VEHICLES (EV)

EV propulsion system consists of three major deviations which is batteries, electric traction motor and last one is, geartrain. This major deviations are disperse in many significance ways such as vehicles performance, vehicles specifications, and many things.

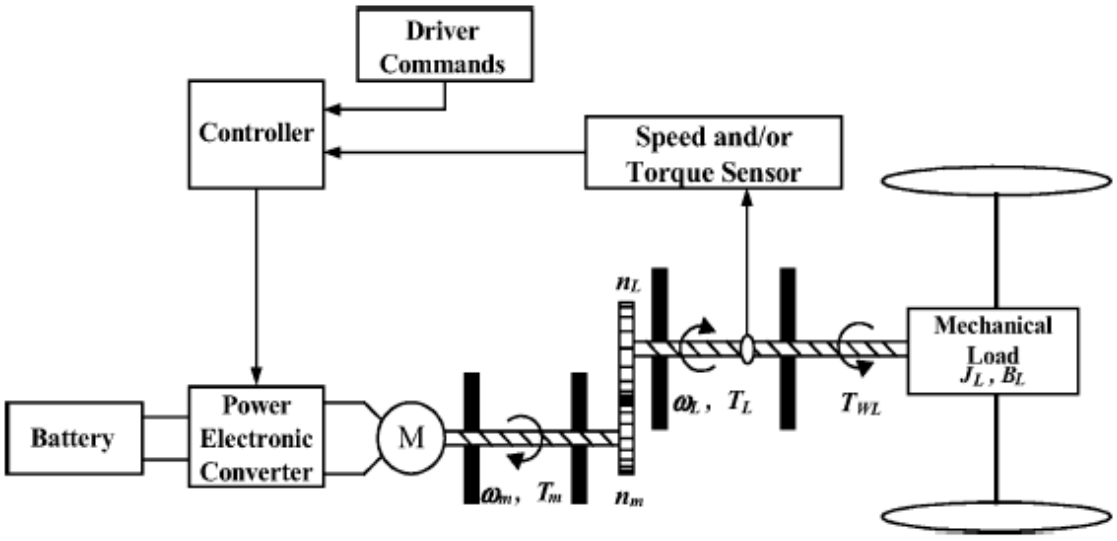

FIGURE 2.1: ELECTRIC VEHICLE SYSTEM.

2.1.1 HEV-HYBRID ELECTRIC VEHICLES (HEVs)

HEV systems are provided by two significant sources of energy which is from internal combustion engine and electric motor. Both of these sources will generate torque to drive the vehicles through the controllable torque transfer unit. For electric motor, there will be two major applications in order to increase the efficiency and performance to supply the energy to the motor. First, electric motor will charge or discharge the battery and second, to regenerative the braking system for optimize the usage of power. In low speed condition, HEV propel itself by using electric motor as a power source in other words, using the power which stored in batteries to move. Internal combustion engine (ICE) becomes a major source to supply a power in order to move the HEV in steady state or constant speed. It is because ICE will operate at its maximum fuel efficiency in that type of speed. Then, in high speed condition, HEV will used both of it source to generate power. There are several term of HEV modes of operation such as low speed running, steady state running, acceleration or hill climbing, battery charging, braking, and last one engine starting[4].

2.2 BATTERY

Electric vehicles (EV) are the vehicles that totally get a power source from it batteries. Then it show that, battery give an important role of moving the EV. There are several characteristics before choosing a suitable battery. There are high specific energy density, high power density, higher life time, high volumetric energy density, ease of charging, and stable performance at low temperature[6].

Nowadays, there still have a problem in making, build and choosing a most suitable battery for EV. This situation happen because battery have been affected by many factor that give a negative impact of battery efficiency and totally performance of EV. Factors that affected the batteries are environment temperature which is non-

uniform, driving pattern such as start the EV, city driving, highway driving and speed of moving, and last one is charging patterns such as variation in battery characteristics and over or under charge cycle.

2.2.1 BATTERY FORMATION

One of the main scope of learning battery process is about it formation. Several external factors that affect formation of the batteries for EV are electrolyte temperature, concentration of the forming electrolyte and current density during the formation cycle.

2.2.2 BATTERY CAPACITY

Capacities of battery give the most important role and function in estimate the driving range of an EV. The capacity measured in ampere hour (Ahr) at a specified rate of discharge and temperature. One of the factors that give high effect to capacities of this item in EV is temperature.

The problem is how to give a maintain temperature especially in Malaysia which have dry and wet weather along the season or year. This problem of maintain uniform temperature of the modules affects the battery life and as a results, it will affect the EV performance. These kind variation of the battery pack temperature are brought by the effects of elevated ambient temperature conditions, inconsistent impedance characteristics among the batteries in the pack and non-uniform pack thermal characteristics.

Two condition that briefly explain is under cold temperature condition and under hot temperature conditions. In cold conditions, the capacities of the battery only at 70% of its rated capacity and under hot conditions, the capacity improve to 20-30%

of the rated capacity. this comparison be made under ideal room temperature conditions. In solving this major problem, in other words to uniform the temperature, some method of thermal management are essentially be used then obtain the peak battery performances.

2.3 ELECTRIC MOTOR

Nowadays, there have two major type of electric motor that often used in Malaysia-AC motor (alternate current motor) and DC motor (direct current motor). From these two type of motor, the suitable one will be chosen. The characteristics or requirement for the motor are the peak power must be 70 to 100 KW (kilowatt), ruggedness (the motor can maintain their performance in rough condition), high torque to inertia, high peak torque capability, high speed operation, low noise be produce, minimum maintenance (in terms of cost to repair or upgrade the motor), small size (suitable for our respective vehicles) and last one, ease to control. The characteristics of AC motor and DC motor described details in table below: