SIMULATION BASED STUDY OF ELECTRIC VEHICLE PARAMETERS

BY

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A research paper submitted in fulfilment of the requirement for the degree of Master of Science in Automotive Engineering.

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ABSTRACT

Electric cars play a clear and important role in solving issues related to the phenomenon of global warming, because when they operate, they do not emit any emissions that pollute the environment, and the electrical network can also be used to organize its work. However, there are still significant problems with electric cars that need to be fixed. The main challenges are all related to the battery package of the car. The battery package should contain enough energy in order to have a certain driving range and power capability. The first step in creating a decent electric vehicle model is choosing the right parameters and comprehending their properties. In this research, the electric vehicles are modelled. Three vehicle model is simulated with three different drive cycles. The simulation result demonstrates the significance of each segment parameter to the performance and fuel economy of electric vehicles. All works are performed in MATLAB/Simulink environment.

ملخص البحث

تلعب السيارات الكهربائية دورا واضحا و مهما في حل القضايا المتعلقة في ظاهرة الاحتباس الحراري وذلك لأنها عندما تتحرك لا يصدر منها أي انبعاثات تلوث البيئة وكذلك يمكن استخدام الشبكة الكهربائية في تشغيل محركاتها. ومع ذلك، لا تزال هناك مشاكل كبيرة تتعلق بالسيارات الكهربائية والتي تحتاج إلى إصلاح. وترتبط جميع هذه التحديات الرئيسية بحزمة بطارية السيارة. يجب أن تحتوي حزمة البطارية على طاقة كافية للحصول على نطاق قيادة وقدرة معينة. الخطوة الأولى في إنشاء نموذج لائق للسيارة الكهربائية هي اختيار الملامح الصحيحة وفهم خصائصها. في هذا البحث تم نمذجة السيارة الكهربائية من خلال دراسة ثلاث نماذج من المركبات مع ثلاث نماذج من دورات القيادة. توضح نتيجة الدراسة أهمية كل معامل كل نموذج في أداء السيارات الكهربائية و الاقتصاد في استهلاك الوقود حيث تم تنفيذ جميع هذه الأنشطة البحثية عبر برنامج الماتلاب.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a research paper for the degree of Master of Science in Automotive Engineering.

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LIST OF SYMBOLS

M	vehicle's total mass
f_m	mass conversion factor
F_t	vehicle's overall traction force
$\sum F_r$	overall force of resistance
G	gravitational acceleration force
ρ	air density
V	vehicle speed
V_W	wind speed
A	car's cross-sectional size
CD	aerodynamic drag factor
F_R	Rolling Force
C_{rr}	rolling resistance coefficient
F_C	gradient's Force
θ	angle of inclination
P	power
P_b	power Battery
$\mathrm{U}p_a$	Electrochemical polar voltage
$\mathrm{R}p_a$	Electrochemical polar Resistance
$\mathrm{R}p_C$	Concentration polarization Resistance
$\mathrm{C}p_a$	Electrochemical polarization Capacitance
$\mathrm{C}p_C$	Concentration polarization Capacitance
Q	Battery capacity
E	No-load voltage
E_0	Battery constant voltage
A	Exponential zone amplitude
K	Polarization voltage
V_a	Terminal Voltage
Ra	armature Resistance
La	armature Inductance
Ea	voltage source of back emf
ω_r	Rotor Angular Speed
λ_f	Field-excitation Magnetic Flux Linkage
P	number of magnetic poles
T_{em}	electromechanical Torque
P_{em}	electromechanical power
P	number of magnetic poles
K	constant

LIST OF ABBREVIATIONS

AC	Alternating Current
AMT	Automated Mechanically Transmission
BJT	Bipolar- Junction Transistor
BEV	Battery Electric Vehicle
CVT	Continuously Variable Transmission
DC	Direct Current
EM	Electric Motor
EV	Electric Vehicle
ESS	Energy Storage System
EDV	Electric Drive Vehicle
FCEV	Fuel Cell Electric Vehicle
FTP-75	Federal Test Procedure
GTO	Gate-Turn-Off
Gan	Gallium Nitride
GHG	Green House Gases
HEV	Hybrid Electric vehicle
HWFET	Highway Fuel Test
IM	Induction Machine
ICE	Internal Combustion Engine
IGBT	Isolated Gate Bipolar Transistor
LDG	Longitudinal Drive Generator
Li-ion	Lithium-Ion
MATLAB	Matrix Laboratory
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
NREL	National Renewable Energy Laboratory
NEDC	New European Driving Cycle
Ni-MH	Nickel Metal Hydride
Ni-CAD	Nickel Cadmium
PWM	Pulse Width Modulation
PHEV	Plug - Hybrid Electric Vehicle

PI	Proportional-Integral
PM	Permanent Magnet
PM BLDC	Permanent Magnet Brushless Direct Current
PM BLAC	Permanent Magnet Brushless Alternator Current
PWM	Pulse Width Modulation
R&D	Research and Development
RB	Regenerative Braking
SOC	State-of-Charge
SIT	Static- Induction Transistor
SITH	Static- Induction Transistor Thyristor
SIC	Silicon Carbide
UDDS	Urban Dynamometer Driving Schedule
VVVF	Variable-Voltage Variable-Frequency
VSI	Voltage Source Inverter
WOA	Whale optimization Algorithm
WLTP	Worldwide Light Vehicles Test Procedure

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Electricity-powered vehicles have been used for transportation for more than 150 years. Early 19th research with magnets led to the invention of electric motors, but they weren't employed for transportation till the mid-1800s, when the first passenger vehicles cars, boats, and railroads were equipped with electric motors (or "automobiles"). Several unique fully electric vehicles for personal mobility were produced because of these studies; several of these dominated the auto industry up to World War One. Typically, Thomas Davenport is credited with creating the first real two-person "electric car" in 1847 and the initial real one-person "electric car" in 1834. In 1851, the first electric vehicle (EV) arrived and moved at a speed of around 20 mph (32 km/h), resembling what we may now refer to as a "car." The Edison Cell, a nickel-iron battery that enabled what was already a booming industry, was developed decades later, leading to the release of the first mass-produced electric vehicles. The batteries used during older EVs, and prototypes lacked the storage capacity that the Edison Cell achieved. They could also be recharged, which enabled automakers to design cars that have been useful for middle-class purchasers who can do so at private or public charge infrastructure (several of which were placed in residences with favourable power tariffs or along city roadways). When it came to recreational vehicles, EVs had a sizable market share by 1900. In 1900, just 22% of the 4200 vehicles purchased in the United States were powered by gasoline, and 40% were still steam-powered. Of them, 38% were electric (Bilgin and Sathyan 2014). Compared to internal combustion engine cars of the time, which were unreliable, stinky, and required manual cranking to start, electric cars were relatively dependable and began right away. The thermal efficiency of the engines was very poor in the steam engine vehicle, the second leading contender, and therefore required illumination (Larminie and Lowry 2012) . Between 1890 and 1914, German and American producers and designers shifted their attention to Electric cars and steam - powered to internal combustion engine by creating thermal engines that could power ships, trains, and vehicles in addition to a wide range of other manufacturing and industrial applications. Henry Ford first presented the mass-produced, gasoline-powered Model T in 1908; this event would have a significant impact on the U.S. automotive industry, which relied on ICEs for propulsion. These affordable vehicles were offered for less than one-fourth the cost of current EVs. Petroleum firms actively encouraged local and regional governments to transition to ICE-powered public transportation systems throughout the 1910s, since many early transit systems had been initially electric (Das 2021). When compared to an ICEV, the EV was overly big, costly to operate, and had severe speed and range restrictions. The electric self-starter, created by Ket'ering in 1912, provided the ICEV a definite edge over steam and the EV, and the ICEV quickly grew in popularity. By the end of the 1920s, the once-vibrant EV had been eliminated from American roads. Following this, research activities experienced a substantial increase in the early 1970s (Fan 1994). Electric vehicles were marketed globally towards the end of the 1970s, and research into EVs didn't pick up momentum again until the late 1980s and early 1990s as a consequence of growing oil prices and environmental concerns. This greatly increased the demand for Batteries vehicles in both commercial and personal cars (Hamut, Javani et al. 2016), (Goodarzi 2018). Today’s electric vehicle technology can really be broken. Down into four technologies.

1.2 DIFFERENT TYPES OF ELECTRIC VEHICLE

The four different kinds of electric vehicles fall into the following categories. The first sort of electric vehicle that comes to mind when people think of them is the conventional electric battery vehicle (BEV). An electric engine, a battery that stores electricity, and a control help to compensate the automobile. A battery charging device, which may be mounted at the charging station or transported on board, is commonly used to recharge the batteries utilizing mains electricity and a connector. The controller can normally manage the voltage given to the motor and, as a consequence, the vehicle speed in forward as well as reverse (Larminie and Lowry 2012). During operations, almost no pollutants may be produced. Compared to ICEs' 30% efficiency, EVs may achieve above 90% efficiency (in the battery). They can also use regenerative breaking, which further boosts their efficiency (Hamut, Javani et al. 2016). To enhance fuel economy, the second kind of vehicle, known as a hybrid electric vehicle (HEV), combines the propulsion systems of an electric motor with a gasoline engine. In a HEV, a system for energy storage (ESS) stores electric energy and provides the necessary power for the motor. Comparison to standard cars of the same size, the majority of HEVs employ a smaller engine and a more potent generator. Additionally, since the motor must supply electricity sent instantly to the motor, the battery system requires to have a larger energy capacity. A second energy-saving function of the motor is also present. When the driver reduces the speed of the car, the actions of regenerative braking are activated. In the braking regenerative, the motor produces energy to brake while also producing electricity to replenish the battery system. When travelling in stop-and-go urban traffic, this helps recover a significant amount of the braking energy that would otherwise be lost in a traditional car. The engine uses less gasoline when travelling at moderate speeds and when the vehicle is stopped at a light thanks to the electric propulsion system. The HEV's control technique ensures that the engine only (or mostly) works in its ideal operating area. There still are three different types of hybrid cars: series hybrid, parallel combination, and series-parallel hybrid (Khandaker 2011). The third type, plug-in motor drives, was developed to increase the driving range of HEVs. PHEVs have a battery that can be charged by the electricity grid and an electric motor. When the car's battery is running low, a conventional engine that can refill or replace it can help. PHEVs use less gasoline than HEVs since they get their electricity straight from the grid. However, like any combination, they have the vexing difficulty of locating a mechanic who is educated about both types of engines. The last alternative is Fuel Cell Electric Vehicles (FCEVs), which combine the characteristics of an ICE and a battery to produce energy through an electrochemical reaction. If a power source is provided by hydrogen, which functions as an ICE's source fuel, it can operate continuously (Basu, Tatiya et al. 2019).

1.3 STATEMENT OF THE PROBLEM

Nowadays, the automotive sector and R&D institutions are very interested in electric vehicles (EV), and environmental activists and policymakers see them as one of the most promising technologies to reduce the concentration of greenhouse gases (GHGs) in the ambience and to enhance the supply security of energy in the nations (Young, Wang et al. 2013).When used as a general-purpose passenger or commercial electrical vehicle, EVs have serious drawbacks that discourage utilisation. Regarding top speed, acceleration, range, load carrying capacity, and recharging time, the EV's performance does not match well to those of a regular vehicle. Additionally, the comfort and convenience features that come standard on conventional vehicles are less useful and less readily applicable to EVs (Fan 1994). But there are still serious problems with electric cars that need to be fixed. The three biggest problems are a short driving range, a long charging period, and a premium price. There are three basic difficulties that are all connected to the automobile's battery system. In addition to having enough energy to cover a particular amount of driving distance, the battery package should also be powerful enough to handle accelerations and decelerations (Schaltz and Soylu 2011). However, to the best of the author's information, no work is carried out for simulation-based study of electric vehicle parameters. Thus, in the current study, an effort is made to study the vehicle parameters. We used MATLAB Simulink software to simulate three segments' vehicles and three different drive cycles to select the best-fitted parameters for driving cycle and car.

1.4 RESEARCH OBJECTIVE

Through scientific advancement in batteries, motors, control systems, and other components, the performance of electric vehicles is now being steadily improved. The parts of the EVs must be modelled and matched to analyse and optimise the operating range, power consumption, and other performance indices. To avoid drawing the erroneous assumptions, a strong EV model is essential (Sun 1997).

This research's main contribution is to study and analysis the vehicle parameters to select the best car and driving cycle less energy consumption parameters.

The study aimed to achieve the following objectives:

1- Modelling and simulation of electric vehicle by using MATLAB Simulink software.
2- Three vehicles (with parameters correspond to their segment) and three driving cycles are selected to test the performance and fuel economy of the designed model.
3- To choose the EV that consumes the least energy and performs best.

1.5 RESEARCH SCOPE

After an exhaustive review of previous work on simulation of electric vehicle parameters, it is found that the solutions were based on methods: modelling and simulation. Most of the work has been found in modelling and simulation work. Some studies have been found in testing methods to select the parametric effect on car. The model of EV is discussed and presented. The simulation of three vehicles is done in MATLAB Simulink. The design model's performance and fuel economy are evaluated through the selection of three driving cycles. The optimal design of EVs will be determined by using the best vehicle segment in further research, which is not covered in this research.

1.6 RESEARCH METHODOLOGY

The first stage in creating a successful electric vehicle model is choosing the right parameters for the vehicle and comprehending their properties in order to better understand the elements that influence them. The established EV model is suggested in this study to considerably increase the overall efficiency of EVs and, therefore, the vehicle range. The study investigates vehicle parameters based on simulation of electric vehicles. To achieve the drive system's powertrain goals,

1- A basic EV have modelled by using software Matlab-Simulink.
2- Suggested three segments—Ford Ka 2008, Ford Focus 2007, and BMW 7 Series 2002—will be executed using the four characteristics we chose: weight, radius of the tire, frontage area, and dragging coefficient.
3- Three distinct driving cycles are recommended for vehicle simulation, including (New European Drive Cycle), (Highway Fuel Test), and (Federal Test Procedure). Work as the signal drive.

The overall aim of this research is to look at how different characteristics affect efficiently a vehicle energy and energy consumption.

1.7 DISSERTATION OUTLINE

This dissertation is organized as follows:

- Chapter 1 discovers a detailed historical overview of EV development as well as a quick review of current EV technology. It also gave context and reason for this research.
- Chapter 2 a detailed survey of previous work based on simulation, and modelling of EV approach.
- Chapter 3 Illustrate a block diagram of the EV system, a flow chart of the programme, and a few numerical models for computer simulation of the drivetrain components are included along with background research on the various types of components used in electric vehicles. Electric vehicles, their types, and characteristics are also presented.
- Chapter 4 mentioned the verifies simulated outcomes by analysing results obtained with the simulation or test results from other references, and vehicle simulation is presented with outcome simulation.
- Chapter5 is covered the result and conclusion. With some recommendations of future work.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter literature review attempts to identify performance of the battery, significant factors influencing range and energy usage, and EV performance features. The building of a whole electric engine and the creation of a complete and accurate electric vehicle model are necessitated in order to construct of a purely electric automotive, A pure electric vehicle requires the creation of a cell, power converter, electric motor, sensors, and control system, as illustrated in figure 2.1 When building an electric system, analysis and simulation techniques must be used from the start of the V-cycle to drive the primary selections.

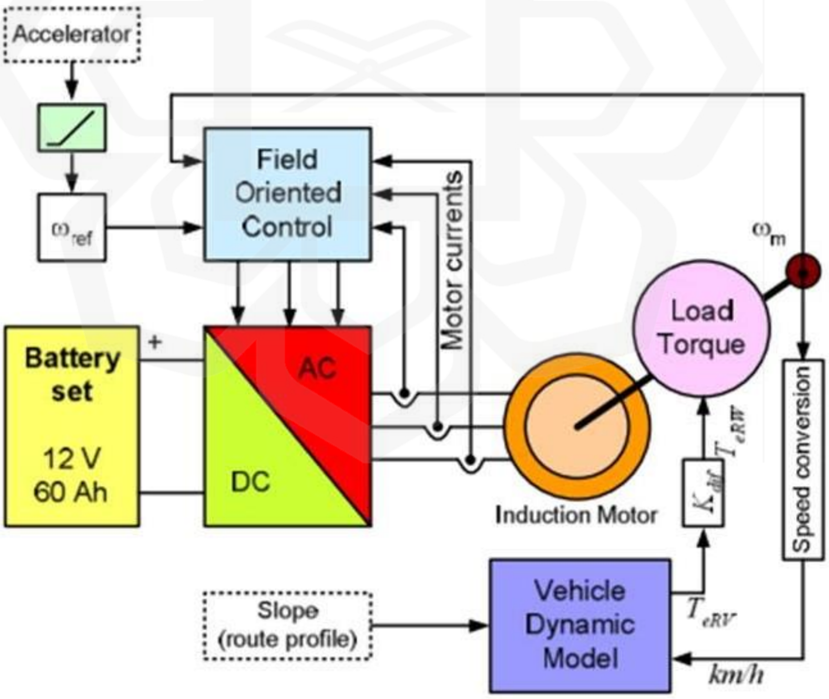

Figure 2.1 Main blocks of the electric vehicle global model (Terras, Neves et al.2010).

2.2 TYPES OF ELECTRIC VEHICLES

EVs might be controlled entirely on electrically or alongside a combustion engine (ICE). A most simple kind of EV that utilizes only employing battery packs as a power supply. These are classified as hybridization electric cars. Automobile employing two or more fuel sources, store devices, or converters should be considered HEVs when at minimum one of them produces electrical energy, according to a proposal made by Technical Committee 69 of the International Electrotechnical Commission (Electric Roads Vehicles). This definition allows for a wide range of HEV combinations, such as ICE with battery, and flywheel combine with energy source as well as capacitor with battery, and fuel cell, and so on. Consequently, as shown in Fig. 2.2, both the citizens and professionals have begun to refer to cars with an ICE and an electric motor as HEVs, cars with such a battery and a capacitor as ultra-capacitor facilitated EVs, and cars with a battery and a hydrogen fuel. Given the widespread use of these terminology, the following categories can be used to group EVs (Un-Noor, Padmanaban et al. 2017).

1. Hybrid Electric Vehicle (HEV)
2. Plug-in Hybrid Electric Vehicle (PHEV)
3. Fuel Cell Electric Vehicle (FCEV)
4. Battery Electric Vehicle (BEV).

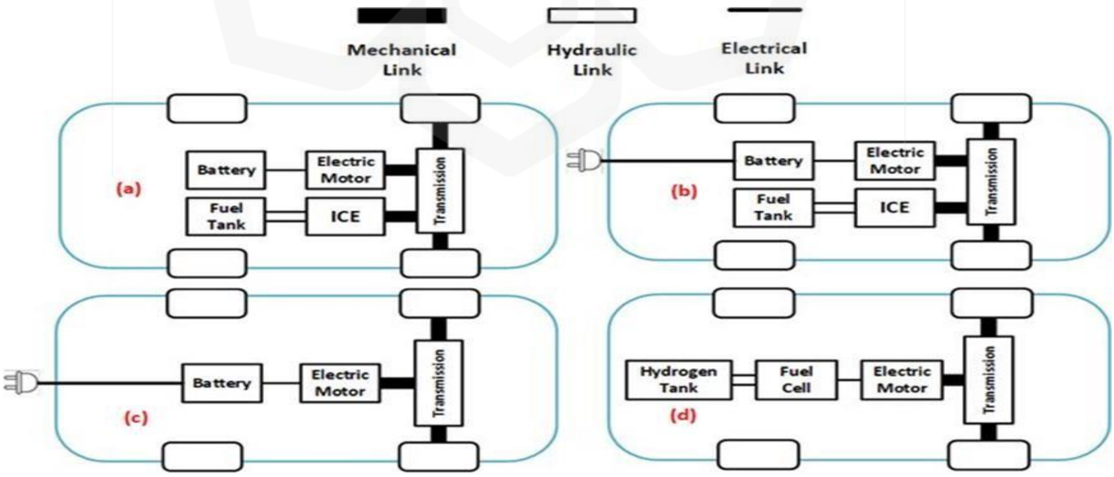

Figure 2.2 basic principles of various vehicles (Morsy, José Pablo et al. 2020).