IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

INVESTIGATION AND ANALYSIS OF ELECTRIC VEHICLES FOR STABLE OPERATING CONDITIONS

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Abstract: This paper investigates the operating conditions of an electric vehicle (EV) for different operating conditions. Various configurations are realized to simulate the output results built-in MATLAB software. EVs are operated for transportation purposes as renewable energy sources replacing oil and gas are used as fuel sources and alternative resources. Electric vehicles have been on the market since the year 2000 and are commonly used in various countries. This analysis gives a new direction in automotive applications while implementing hardware configuration**..**

***Index Terms* - Electric vehicle; renewable energy; plug-in-hybrid electric vehicle; internal combustion.**

I. INTRODUCTION

In the present scenario, the fuel demand is high, and consumption increases. Due to the uses of these fuels in vehicles, CO_2 gas dissipated significantly. The carbon dioxide gas affects the environment varies badly. CO_2 reduction is the main challenge, and it can be achieved by an Eco-friendly vehicle or car called an Electric vehicle (EV). Due to the increasing cost of fuel in the present days, the fuel cell vehicle is not economical. The EVs are very economical due to their driven process achieved by an electric motor. They do not pollute the environment. The cost of the batteries and motors is stable, so EVs prefer fuel-based vehicles. The EV is developed by the motor, battery, controller, converters, and wheels. The motor is connected to the differential of the wheels.

Fig. 1.1 shows the block diagram of the electric vehicle. The schematic arrangement of the EV drive train configuration. In this configuration, a battery pack is used to provide the dc energy to the circuit, which is further connected to the inverter circuit. In this basic configuration of EV, four wheels are used. Two wheels are connected in the front portion, called front-wheel drive. The rest of the two wheels are connected at the rear portion of the drive, so it is called virtual wheel drive. Both the end wheels are connected through the differential. The differential is balanced to the rear and front wheel drive system. The differential portion represents a gear mechanism that allows the driven shaft to spin at different speeds. The fidelity of the gear model improved by specifying the parameters of the differential gear system, like gear inertia, meshing, and viscous losses. A battery pack is used as the source of the EV model. A lithium-ion battery fixed in the modeling of EV provides input supply to both the motors connected across the front and rear end of the model. The induction motor and synchronous motor used for the driven portion of the electric vehicle due to their several advantages, as studied earlier. A squirrel cage induction motor is connected to the rear wheel due to high efficiency and high starting torque requirement. An induction motor has both characteristics efficiently. The high starting torque demand is completed by the induction motor, which helps the electric vehicle in the initial stage. At the front wheel portion, the synchronous motor is connected due to its high-power density and constant speed characteristics. The control operation is performed by the inverter, which provides three phase AC supply to the induction and synchronous motor.

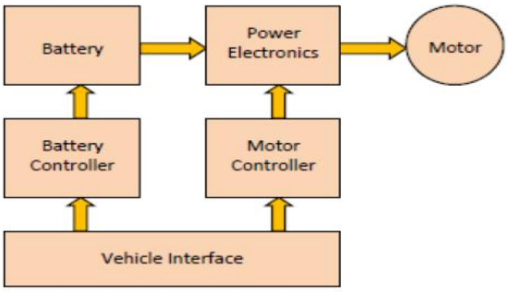

Fig.1.1 Representation of block diagram of EV

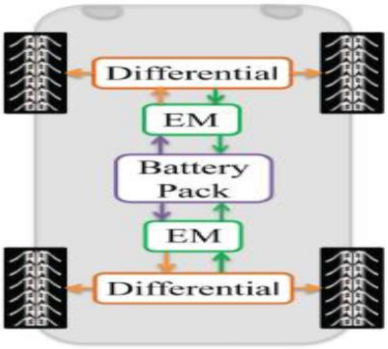

Fig.1.2 EV arrangement of layers

In this basic configuration of EV, four wheels are used. Two wheels are connected in the front portion, called front-wheel drive. The rest of the two wheels are connected at the rear portion of the drive, so it is called actual wheel drive.

II. LITERATURE REVIEW

Because of current battery technology, electric vehicles are still limited by their range; although recent battery improvements have aided commercial implementation, the widespread application continues to present significant challenges. An alternative method to circumvent the battery range issues of electric vehicles is to consider the recent success of hybrid electric vehicle technology, which combines electric motor fast acceleration characteristics with internal combustion (IC) engine that allows operation at a constant speed and full load, resulting in improved efficiency and lower emissions. A recent development is an option of recharging the battery when the vehicle is not in use. The Plug-in Hybrid Electric Vehicle (PHEV) model aims to overcome the range limitation, thus removing any impediment to the use of electricity as part of the energy mix for mobility applications. PHEV allows vehicles to operate in pure electric mode for short driving distances, in combined electric and fuel modes for urban driving, and mainly in fuel mode for highway driving when the driving range is critical and recharging is not practical. With more choices of energy sources, significant reductions in vehicle emissions and greenhouse gases are possible without 'upstreaming' these emissions, as often occurs for many proposed energy utilization scenarios that require energy conversion and storage steps that decrease second-law efficiencies. The PHEV architecture should provide one of the best energy scenarios for transport vehicles, allowing a combination of energy sources that include renewable electricity and renewable biofuels. It also allows biofuels to occupy a more significant proportion of the fuel energy mix for mobility applications, given supply of biofuels is limited. In jurisdictions where significant non-emitting energy can be produced (Canada, Brazil, France), the application of PHEV achieves the goal of near-zero emission vehicles.

More importantly, PHEV improves the advantage of electric vehicles when using electricity as part of the mobility energy mix: only approximately 10% of the electric energy is lost during battery storage, compared to more than 60% when converting electricity to hydrogen and back to electricity when using fuel cells [**1**-**4**]. Hybrid electric vehicles can be configured in series and parallel. In a series configuration, no power is transferred mechanically between the fuel engine and the wheels: the fuel engine powers a generator, which in turn can both charge the batteries and deliver power to the motor. The electric motor powers the wheels. In the parallel configuration, there is a direct mechanical connection from the electric power unit and the fuel engine to the wheels.

Moreover, through public education, it is hoped that eventually, PHEV will be demanded by consumers as they favor the direct use of electricity above other energy sources, understanding that it results in a much more limited environmental impact. Researchers focus on understanding hybrid vehicles' dynamics by developing simulators. The results can be used to optimize the design cycle of hybrid vehicles by testing configurations and energy management strategies before prototype construction begins. Power flow management, optimization of the fuel economy, and reduction of emissions using intelligent control systems are part of the current research [5–20]. For example, in *Kheir et al.* [7] an attempt is made to balance fuel usage and emissions as a performance index, with the PSAT rule-based controller being used for comparison. *Bowles et al.* [8] established an inverse hybrid vehicle model via Matlab/Simulink. Interest in hybrid vehicle simulation grew in the 1970s with the development of several prototypes that were used to collect a considerable amount of test data on the performance of hybrid drive trains [11]. Total hybrid electric vehicles, such as the Toyota Prius, were studied in [15, 16]. A vehicle simulation software platform based on IDEAS. Simulation Inc. software [21, 22], was used to develop the proof-of-concept for PHEV.

The previous work reflected in the past literature motivated the authors the investigation and simulation analysis of EV.

III. SYSTEM CONFIGURATION

The system requirements we have considered for the Simulink model are represented below in order to analyze the output results. These parameters are incorporated in this model for the simulation outputs.

a. Overall System Requirements

The following requirements apply to the HEV dimensions:

1.	Curb Weight:	1325 kg
2.	Length	4450 mm
3.	Width	1725 mm
4.	Height	1490mm

Performance criteria

1.	Total Range	870 km
2.	Electric Range	18 km

b. Engine System Requirements

The following requirements apply to the functionality of this module.

ICE:

1.	Power	57 kW @5000 RPM
2.	Min Speed	1000 rpm
3.	Max Speed	4500 rpm
4.	Torque	115 Nm @ 4200 RPM

c. Fuel Consumption

The following requirements apply to the fuel consumption:

Regular Gas:

1.	City	51 MPG
2.	Highway	49 MPG
3.	Combined	50 MPG

Electric + Gas:

1.	Combined	95 MPG

d. Speed Controller Module Requirements

The following requirements apply to the Speed Controller module:

2. The controller module will implement at a minimum proportional and integral control.
3. Upon a change of angle, the system must be within 5% of the final value within 0.1 seconds (Settling Time).
4. Upon a change of 10% the system must achieve 10% of the final value within 0.7 seconds

e. Current Controller Module Requirements

The following requirements apply to the Current Controller module.

The current must remain within 1% of the command value.

IV. RESULTS AND DISCUSSIONS

The current EV model is analyzed in simulation model at MATLAB 2019A software environment. These are realized by configuration-1 and configuration-2. The current model is depicted in Fig. 1.3.

Configuration-1: The Simulink EV model

Configuration-1 is represented below for the analysis and simulation of curves.

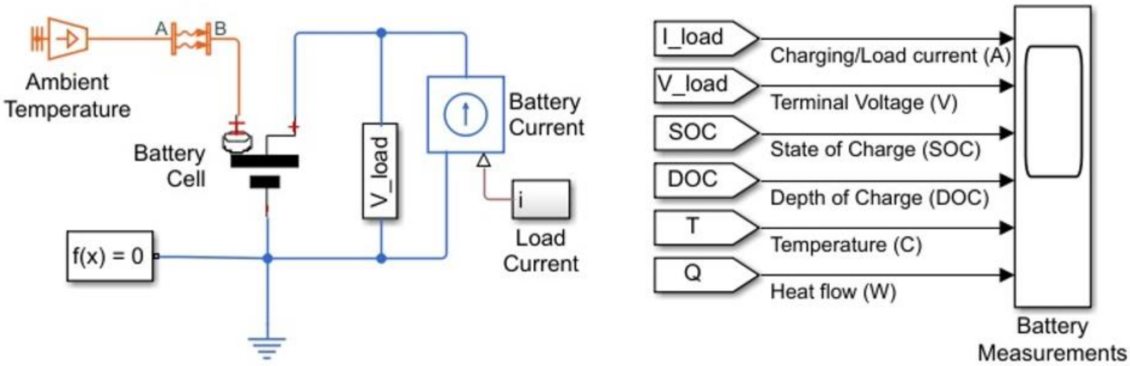

Fig. 1.3 The proposed simulation model of EV model

In the beginning, this mode shows up when the key associated with the battery source is turned on the front and back tire drive engines get the stock and begin working. Furthermore, the EV begins speeding up, and the created reference force from the gas pedal disperses to the back tire drive framework. Immediately after detecting the rotor position, it moves to typical mode activity, which is well disseminated to the front drive framework. The following figures show the correlation of front-wheel drive framework speed. Here, it is seen that un-advanced Speed is wavering to its reference speed; this is on the grounds that customary PI regulators are utilized in this stage. This can bring about temperamental guiding and seed tasks, and a lot of endeavors are expected to make EV stable. This wavering velocity likewise makes a security issue for travelers.

Additionally, the un-improved EV drive framework requires just about 4 seconds to make the Speed consistent. Then again, by utilizing an enhanced regulator, we can get steady Speed which is practically equivalent to the front wheel drive reference speed. Likewise, to the decreased speed blunder, the regulator takes a tiny season of 0.25 seconds to achieve its reference esteem. And furthermore, with the assistance of enhanced work produced, wavering in EV speed is killed. In the back tire drive, framework speed bends are displayed in following figures. This Figure shows that this Speed becomes steady in significantly less time and the back tire drive speed additionally becomes synchronized with the front wheel speed of 1600 rpm.

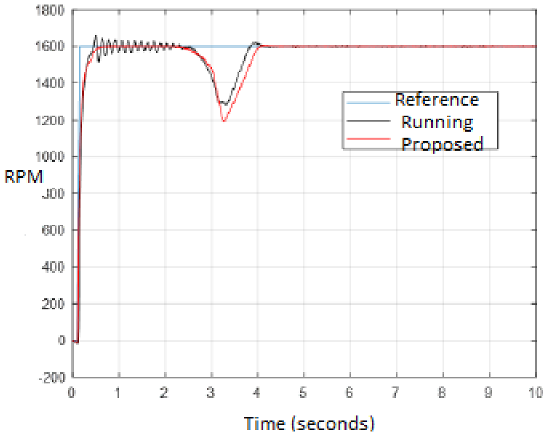

Fig. 1.4 Speed vs time curve for EV vehicle

The various operating curves are illustrated in the below figures while investigating the simulink model of EV model.

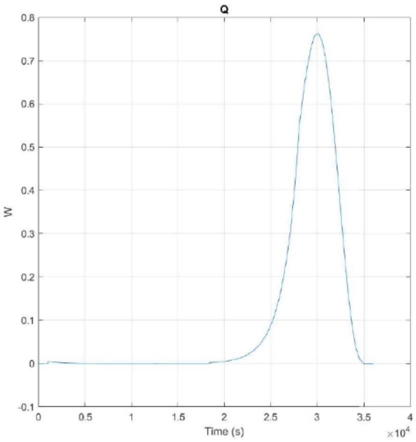

Fig. 1.5 Active power curve

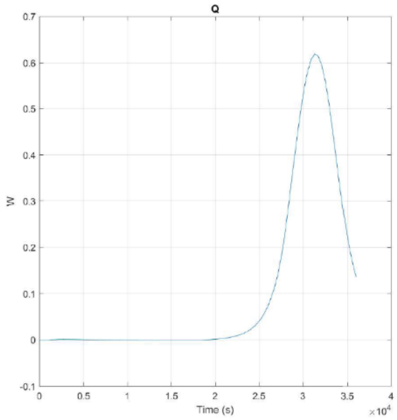

Fig. 1.6 Ambient temperature curve

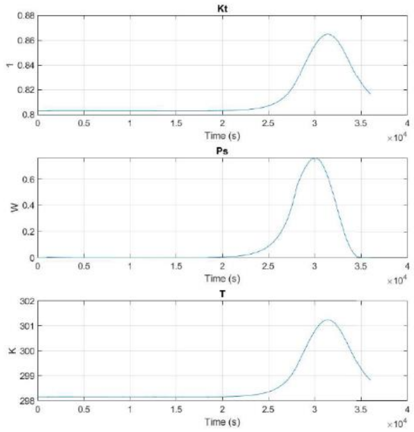

Fig. 1.7 Battery thermal model curve

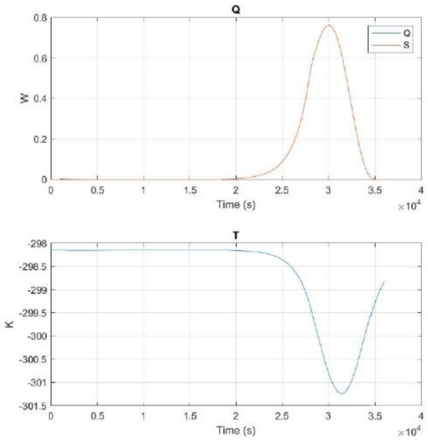

Fig. 1.8 Controlled heat flow curve

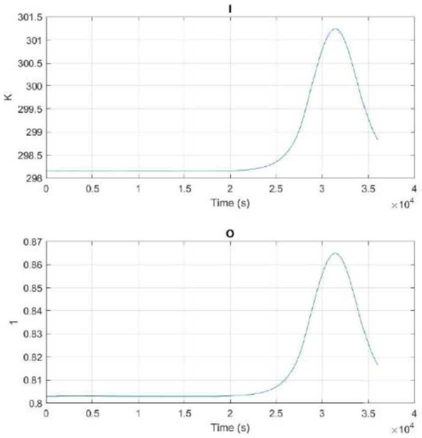

Fig. 1.9 Current vs time curve for configuration-1

Configuration-2:

The upcoming results curves are investigated in the simulation model of the system built in MATLAB 2019A. The various parameters are taken for analyzing curves from Fig. 1.10.

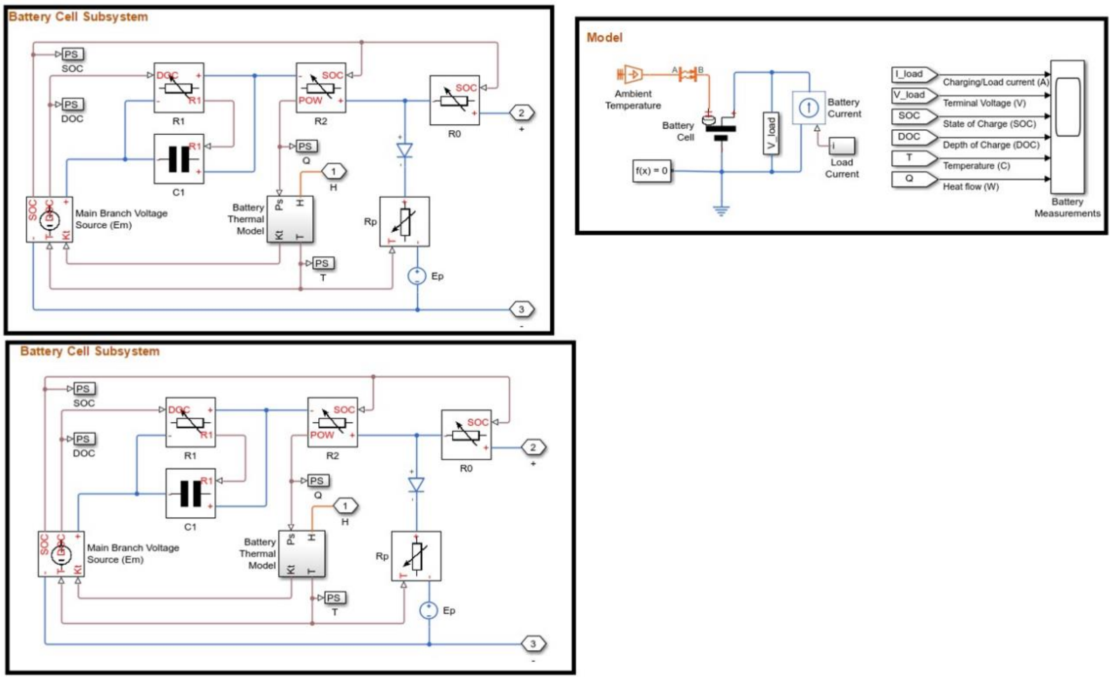

Fig. 1.10 Simulink model depicting various systems

The output results considering the above parameters with different operating curves are represented below.

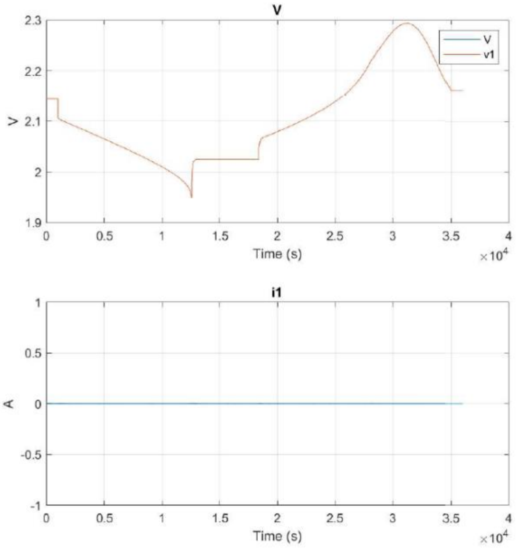

Fig. 1.11 Operating curves using voltage sensors for the configuration-2

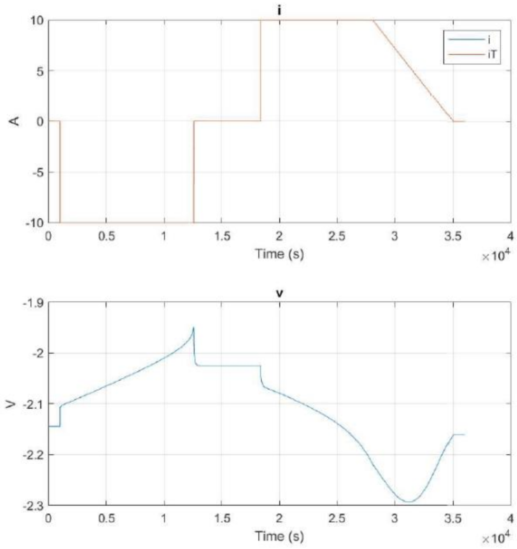

Fig. 1.12 Operating curves with current and voltage plot for the configuration-2

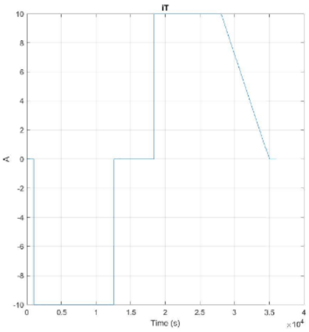

Fig. 1.13 Current vs time plot for the configuration-2

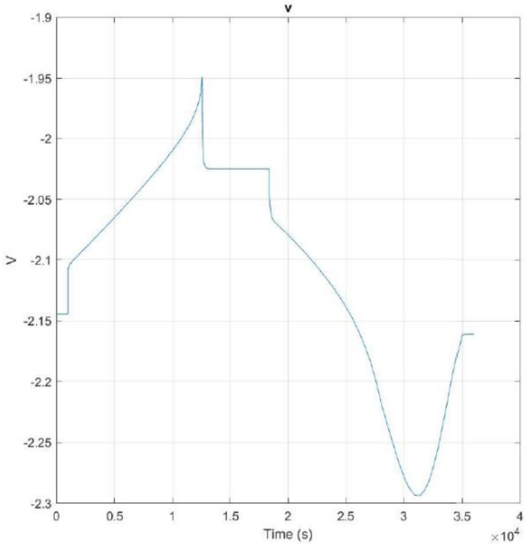

Fig. 1.14 Voltage vs time plot for the configuration-2

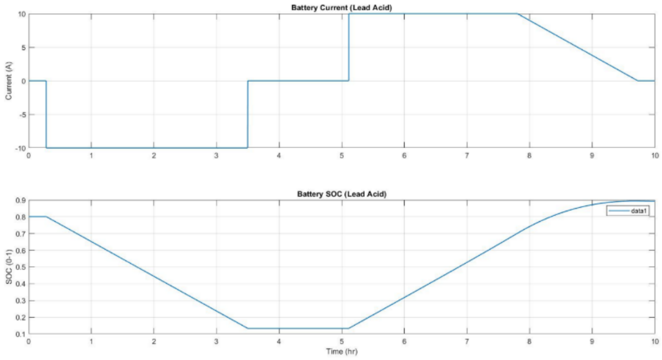

Fig. 1.15 Operating curve of the battery for the configuration-2

The above plots of the outputs results depict the various investigation performed for the considered configuration.

V. CONCLUSION AND FUTURE SCOPE OF WORK

The two configurations for simulation and analysis have been considered for the EV model. The essential contribution of the project is outlined below:

a. Integrating the requirements in the model and simulation is critical for effective development
b. Effective use of control design tools and optimization algorithms improves the overall design
c. Simulating plant and controller in one tool allows engineers to understand and optimize the performance of the entire system

This can be enhanced for the hardware implementation in the near future scope of work.

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