

Sensitivity of Design Parameters on State of Charge of Electric Vehicles

Abhi Ram K, A Srinivaas



Abstract: Paper This study is to find out how sensitively the design parameters of Electric Vehicle (EV) will affect the State Of Charge (SOC) it. The main design parameters that selected are the frontal area of the vehicle, vehicle mass and coefficient of drag. With the help of Advisor software MatLab model of EV s made. The vehicle model is run in different universally accepted driving cycles with different values of design parameters selected. The analysis is done using the sensitivity analysis method, which will show how one parameter is affecting others.

Keywords: Electric vehicle, State of Charge (SOC), Advisor, MATLAB

I. INTRODUCTION

Nowadays global warming is becoming the major issue for the world. Carbon dioxide emission is of the main reason for the global-warming. The main percentage of the carbon dioxide is contributed by the automobiles. To find the solution for this the automobile industry is changing rapidly. In the current era, Electric Vehicles (EV) are coming as the future. The electric vehicle has zero tailpipe emission. In EV s energy is stored in a battery. Electric motors are connected to the battery and that's how the motors work. Electric Vehicles can be defined as those vehicles which are run by an electric motor. The EVs mainly has three subsystems, they are

1. Electric Propulsion Subsystem
2. Auxiliary subsystem
3. Energy source

The electric-propulsion subsystem contains the electronic-controller, Powerconverter, Mechanical transmission, Driving wheels and Electric Motor. The auxiliary sub system contains power steering unit, Auxiliary power supply and Temperature control unit. The energysource sub-system mainly contains the energy management unit, energy refuelling unit and energy storage unit. The main challenge in EVs is the range of vehicle in one single charge.

Researches are going on to find out the best batteries to get the maximum range for EVs. To increase the range of vehicle not only we want to increase the battery efficiency and capacity also want to consider the design parameters.

The optimisation of design parameters can also lead to increasing the range of the vehicle. This paper discusses how the different designing parameters such as the vehicle-mass, the vehicle frontal area of the vehicle and coefficient of drag of the vehicle will affect the State of Charge (SOC) of the vehicle.

II. EV MODEL

For getting accurate results from the analysis the model should be highly precise.

For generating these high precise model software called ADVISOR is used to create the Simulink model of EV. Advanced vehicle simulator is a modelling and simulation software which will provide state of charge of the vehicle at different time interval for a different driving cycle.

The vehicle performance can be analysed by using two models, forward and backwards-facing model. In the forward facing model, we want an exact driver model with power and torque every time.

But in the backwards-facing model, we only want to know the speed of the vehicle at each time step.

For the analysis of the project, a backwards-facing model is used.

For generating the vehicle model the equation used is solid body motion equation.

$$F = mgCrr + \frac{1}{2} \rho C_D A v^2 + ma + mg \sin \theta \quad (1)$$

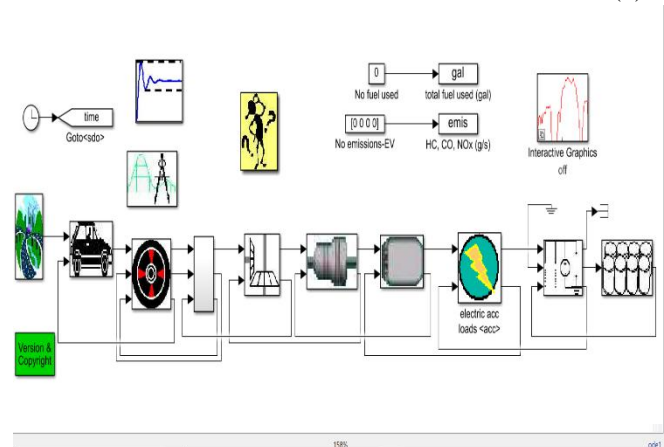


Fig 1. EV Model in Simulink

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III. SENSITIVITY ANALYSIS

The method used for data analysis is sensitivity analysis. Basics behind the sensitivity analysis are varying one of the input variables and keeping the others variable constant. If δX and δy represent the change in the value of the variables x and y respectively. Then sensitivity of y on x can be written as

$$S_{x,y} = \frac{\partial x}{\partial y} \frac{y}{x} \quad (2)$$

SOC of a battery can be defined as the actual power capacity of battery with respect to the saturated power capacity of battery. SOC index (SOC_i) can be calculated as

$$SOC_i = \frac{SOC_i - SOC_f}{SOC_i} \quad (3)$$

Where SOC_i is initial SOC and SOC_f is final SOC

$$S_{soc_i,m} = \frac{\partial(SOC_i)}{\partial M} \frac{M}{SOC_i} \quad (4)$$

$$S_{soc_i,fa} = \frac{\partial(SOC_i)}{\partial(FA)} \frac{FA}{SOC_i} \quad (5)$$

$$S_{soc_i,cd} = \frac{\partial(SOC_i)}{\partial(CD)} \frac{CD}{SOC_i} \quad (6)$$

Where M is the mass of vehicle, FA is the frontal area of vehicle and CD is the coefficient of drag.

IV. RESULT AND DISCUSSION

The simulation is carried out by using standard driving cycles like UDDS, US0, SC03 and HWFET. These driving cycles are shown below

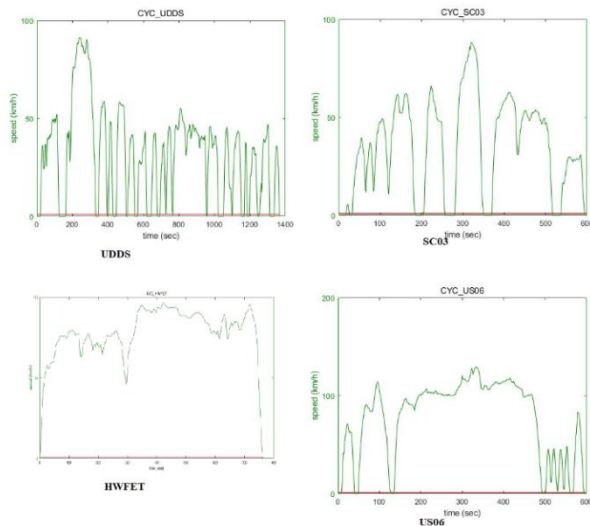


Fig 2 Driving cycles

The out put from the simulation is plotted as a bar chart for better understanding and analysis.

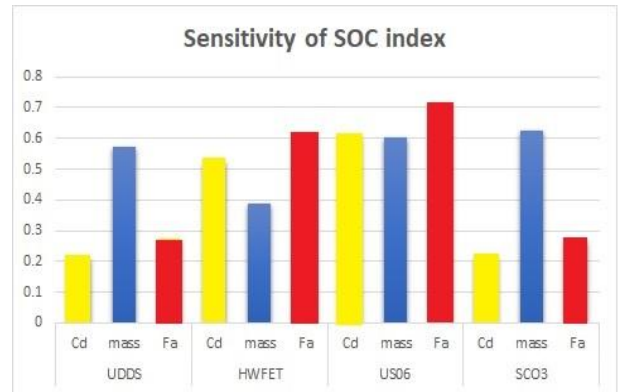


Fig 3 Sensitivity of SOC index

From the graph it is found that in UDDS driving cycle Mass have more impact on SOC of battery. Similarly, in SC03 driving cycle also mass is predominant. UDDS and SC03 driving cycles shows almost similar trends. Second more influencing parameter is frontal area for both the cycle and coefficient of drag comes third.

In HWFET and US06 driving cycle frontal area is most sensitive in SOC index. HWFET and US06 shows almost same trend. Second most sensitive design parameter is coefficient of drag for both driving cycle and third one is mass of the vehicle.

Table I Comparison of Sensitivity of SOC_i of HWFET and US06

HWFET			US06		
Cd	mass	Fa	Cd	mass	Fa
0.530068	0.389419	0.610507	0.606784	0.603963	0.713867

UDDS and SC03 shows same trends because when we looking at the driving cycle both the driving cycle are fluctuating, which means there is no constancy in speed. So for a driving with continuously fluctuating speed the mass will become higher sensitive to the deciding of SOC of battery

Table II. Comparison of Sensitivity of SOC_i of UDDS and SC03

UDDS			SC03		
Cd	mass	Fa	Cd	mass	Fa
0.213708	0.572495	0.266735	0.21823	0.626526	0.270016

The following interference can be made from the graphs and tables. For the driving cycle with rapid variations in speed such as UDDS and SC03 mass comes as major influencing thing in SOC.

For the driving cycle with rapid variations in speed such as UDDS and SC03 frontal area and coefficient of drag shows almost same sensitivity to SOC.

In Driving cycle with high speed and more smooth speed variations such as US06 and HWFET Frontal area shows more sensitive to SOC. In Driving cycle with high speed and more smooth speed variations such as US06 and HWFET mass is less sensitive to SOC.

V. CONCLUSION

This study concentrated on how different design parameters such as mass of vehicle, coefficient of drag and Frontal area will affect the SOC of EVs. For predicting the range of vehicles, the SOC is the basic factor. So this study shows that the SOC is influenced by these design parameters. But their sensitivity towards SOC is different in different driving conditions. So, when calculating the range of EVs the influence of these parameters should also want to consider. Only four different driving cycles are considered in this study. For more result in future more driving cycles and custom driving cycle can be used for study.

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