ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.7

Drive Cycle Analysis for Electric Vehicle using MATLAB

Anuja R. Jadhav
ME (Embedded & VLSI)
Department of Electronics & Telecommunication
G. H. Raisoni Institute of Engineering and Technology, Pune, India

Abstract:
Today most of the humans are used the motor vehicles. These motors vehicles are produced the problems such as air pollution & global warms Also the humans are facing the issue of reduction of oil in the world. In recent years, the researchers studied that problems and found the alternative energy source to drive the vehicle. One good way is to replace the combustion motor with an electric motor, which is called as electric vehicle (EV). In recent days EV's are gaining more popularity. Solar powered electric vehicles (SEV) are considered the future vehicles to solve the major issue related to the environment. Energy management system (EMS) in SEV is very important because this type of vehicle is highly depends on supply of battery. So, Battery plays an important role in SEV. With the help of renewable sources such as solar energy the efficiency of the SEV may be increased. For an SEV, motor selection is very important parameter. A particular motor may behave differently under different driving conditions. In this paper, solar powered small electric vehicle is designed by using the mat lab and the analysis of different drive cycles for urban or suburban region.

Keywords: Electric Vehicle (EV), Solar panel, Lead acid battery, DC motor, MATLAB.

I. INTRODUCTION

In recent decades demands for vehicles are increased that caused the environmental pollution everywhere. The fossil fuel such as petrol and diesel are expensive. Consumption of fossil fuel for vehicles is more increasing. More than half of world energy consumption is used for transportation. Figure 1 illustrates the differences between fuel demand and world oil production after the year 2020.

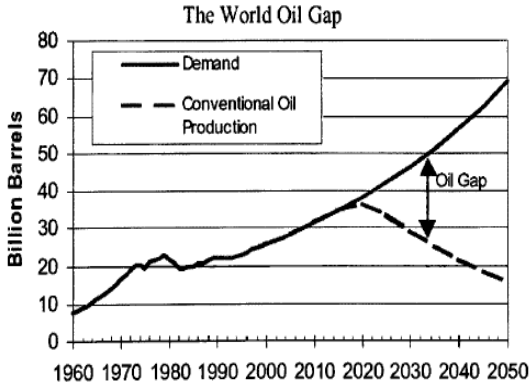


Figure.1. World oil demand by 2050 (Image courtesy of Bambang Sri Kaloko, Indonesia)

The use of fossil fuel based vehicle causes the air pollution which is very harmful for the human beings. The noise level of these vehicles is high which is directly affected on human body that causes the heart attack. Fuel gases produced by vehicles consist of 18% solid particles, 27% mixture of volatiles (comprising 28% Pb, 32% NO and 62% CO) and CO2 by 25%. To avoid these problems researchers found a new technology called Solar Electric Vehicle (SEV). There are many renewable sources such as solar energy, Wind energy, Tidal energy for reducing the environmental pollution and saves the electricity. One of the greatest energy sources is the solar energy. In SEV, Solar energy is converted the sun energy in to electrical energy and stored in the batteries and this stored energy is utilized for EV. Battery is the crucial parameter of EV. In this paper, Battery is charged from solar panel as well as power supply. The performance of EV is evaluated for various drive cycles. Here three drive cycles are considered that are flat, slope & rough surface and these drive cycles are analyzes on MATLAB.

II. METHODOLOGY

A. PROPOSED DESIGN

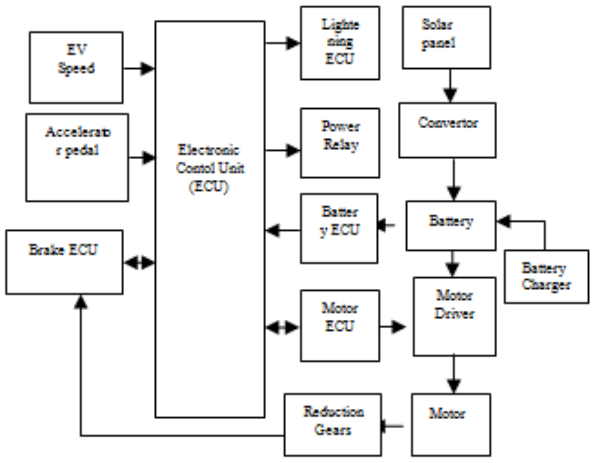


Figure.2. General Block diagram for EV.

Above figure shows the general block diagram of EV having different control units like lightening ECU, Battery ECU, Motor, and Gears etc. In this section, a small solar powered EV is designed using MATLAB software. In this system Solar, battery, and motor plays the important role. To increase the efficiency of EV we used the renewable energy source i.e. solar energy.

Battery is a device which can be charged from either solar panel or power supply. The performance of EV is evaluated by using various drive cycles (flat surface, rough and slope surface) and these drive cycles are analyzed on MATLAB.

PRINCIPAL OF OPERATION

1. Solar panel:

Solar panel is used to convert the solar energy to electrical energy. Silicon is one of the materials used in photovoltaic cell to convert sun's energy into electricity.

Table.1.Specification of solar panel

Number of solar panel	1
Max power voltage	48v
Max power	1000W
Efficiency	40%

From the above given data we can calculate the panel current,

$$I_p = \frac{C_p \times Efficiency}{V_p}$$

Where,
I= Panel Current.
P= panel Capacity.
V= panel voltage.

2. Battery:

Battery is a device, which maintain current by transferring chemical energy into electrical energy. In this paper battery can stores the solar energy and this energy is given to the motor. So that motor will be run with fast speed and vehicle will be run. In this project we use the lead acid battery.

Table.2. Specification of Battery

Battery type	Lead acid battery
Voltage rating	48 V
Battery capacity	400AH
Fastest possible charging time	4Hr
Efficiency	0.8(20% loss)

Discharge Current formula,

Discharge Current= $Batt\ current - Panel\ current$

$$I_d = I_b - I_p$$

When, Battery current > no load current

Battery life calculation formula,

$$\text{Battery life} = \frac{Battery\ capacity \times Efficiency}{Discharge\ current} = \frac{C_b \times Efficiency}{I_d}$$

3. Motor:

The motors used in electric cars can be AC or DC. Mostly DC motors are preferred than AC motors because they are simple to configure, not expensive and lossless than the AC. There are different types of motor used in EV that are Brushless DC motor (BLDC), Induction Motor (IM), Permanent Magnet Motor (PMM) and Switch Reluctance Motor (SRM). In this project DC motor is used.

Table.3.Specification of DC Motor

Max power voltage	48v
Stall Torque(Ts)	30Nm
Motor Torque	10Nm

Characteristics of DC motor with load and without load

- **No load**

Formula for Motor Torque,

$$T_{Motor} = T_S - \frac{(w \times T_S)}{w_n}$$

Where, T_{Motor} = Motor torque.
T_S = Stall Torque.
W = Wheel Angular Velocity
w_n = max velocity

Graph 1 shows the speed vs. torque characteristics for no load.

- **With load**

T α I

T= Torque constant * I

$$Torque\ Load = \frac{D(F+\mu Wg)}{2}$$

Where, D = Diameter of wheel.
F = External force.
W = Weight of vehicle.
g = Gravity Acceleration
μ = Frictional Coefficent

$$\text{Current due to load} = \frac{Torque\ load}{Torque\ constant}.$$

Formula for motor current,

Motor current= *No load current + current due to load.*

Graph 2 shows the current vs. torque characteristics for load.

B. DRIVE CYCLE ANALYSIS

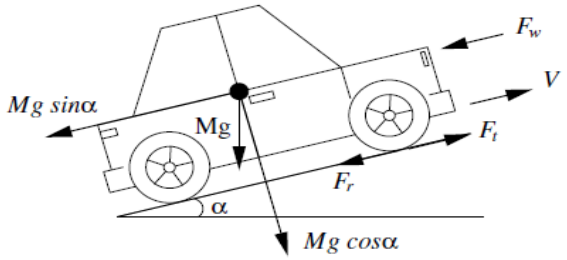


Figure.3. Forces acting on moving vehicle

Drive cycles is important for comparative analysis and motor selection purpose. Drive cycles defines the characteristics curve of speed, torque and current of the vehicle. Various forces acting on a moving vehicle are shown in fig4 and are discussed in this section. First step is to make a tractive force to determine how much load on the electric vehicle to a flat, rough and slope road condition. The traction force (F_t) is made up of the different driving resistance forces and is defined as,

$$F_t = F_r + F_w + F_g + F_a$$

Where, F_t = Traction Force
F_r = Rolling Force
F_w = Aerodynamic drag Force
F_g = Grade resistance Force
F_a = Acceleration Force

The F_r is caused by the tire deformation on the road and is defines as

$$F_r = Mgf_r \cos(\propto)$$

Where, M = Mass of the vehicle

g = Acceleration due to gravity

f_r = Rolling resistance coefficient

$\propto$ = Road angle

The F_w is the force on the vehicle that caused by the vehicle aerodynamic and defines as

$$F_w = \frac{V^2 \rho A_f \, C_d}{2}$$

Where, V = Vehicle Speed

A_f = Vehicle surface area

C_d = Aerodynamic drag coefficient

ρ = Air density

The F_g is the force on the vehicle to move up or move upward with a slope.

$$F_g = Mg \sin \propto$$

The acceleration force is the force required to increase the speed of the vehicle and defines as

$$F_a = \lambda M \frac{dv}{dt}$$

λ is rotational inertia constant. The total tractive torque (T_w) required at the wheel is given by

$$T_w = F_t \times r$$

Where r= radius of wheel

And total tractive power (P_w) required at the wheel is given by

$$P_w = F_t \times V$$

The first step towards the design of the power train is to select the type of motor used in EV. Before plotting the curves, it is important to simulate the vehicle under different driving environment. In this project, there are three cases are considered. These drive cycles are simulated in MATLAB software.

Drive Cycles:

- Flat Surface (Highway).
- Rough Surface (City).
- Slop Surface.

Table.4. the Specifications of EV in

Electric Vehicle Specification	Size
Weight	500kg
Friction Coefficient	1
Roller diameter	0.508m
Gravity Acceleration	9.8m/s2
External Force	100N
Battery Type	Lead Acid Battery
Motor Type	DC Motor

III. RESULT

The performance of EV is evaluated for various drive cycles. Different drive cycles are analyzed on MATLAB. Following figures shows the general characteristics of motor and battery & Drive cycle analysis.

a. Battery Discharging Graph

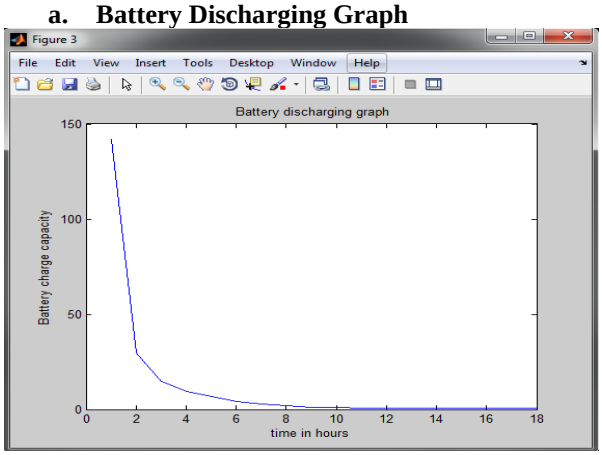


Figure.4. Battery discharging graph

Above fig3 shows the battery discharging graph. Here battery capacity is 150Ahr taken. From above fig3 it is observed that battery discharged time is 6hr for speed 80km/hr.

b. Speed vs. Torque

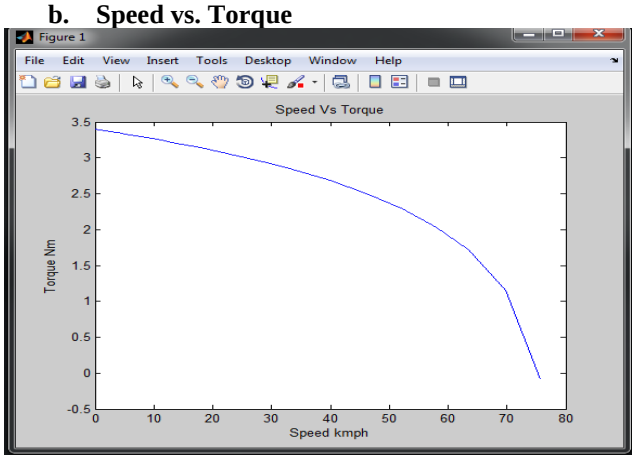


Figure.5. Speed vs. Torque graph

Above fig4 shows the general characteristics of motor used. Here vehicle speed is taken 80km/hr and torque is 3.5Nm for no load. If the speed of the vehicle is increased from 10 to 80 km/hr then torque of the motor is decreased.

c. Torque vs. Motor Current

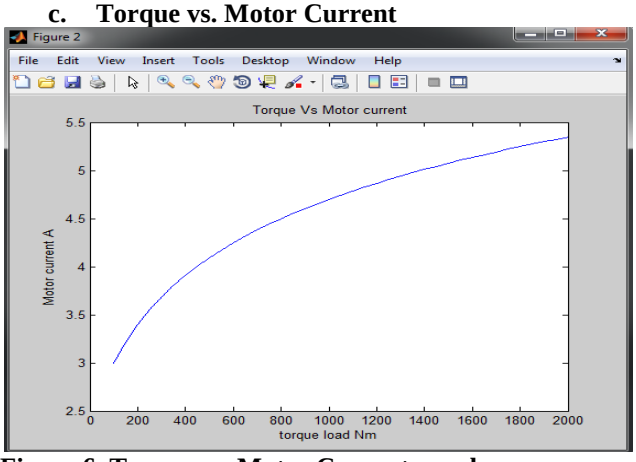


Figure.6. Torque vs. Motor Current graph

For the above same condition, the current drawn by the motor is plotted in fig5. If the load is present then the maximum current is 5.5A and the torque load is 2000Nm. From above fig5 it is observed that the torque is directly proportional to the motor current.

d. Drive Cycle for Flat Surface

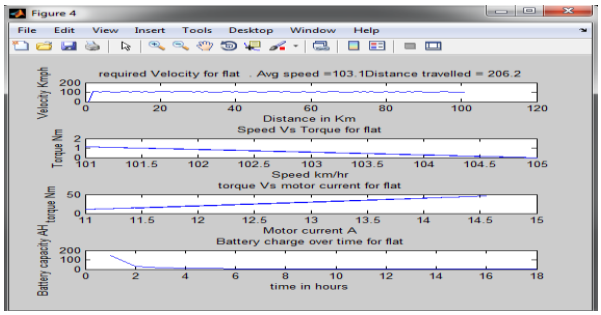


Figure.7. Different Curves for Flat Surface

From the fig6 it is observed that for 2 hrs average speeds are 103Km and distance travel is 206.2km/hr. If the vehicle speed is increased from 101 to 105km/hr then torque is low. For the same condition the motor current is 14.5A then the torque is 50Nm.

e. Drive cycle for Rough Surface:

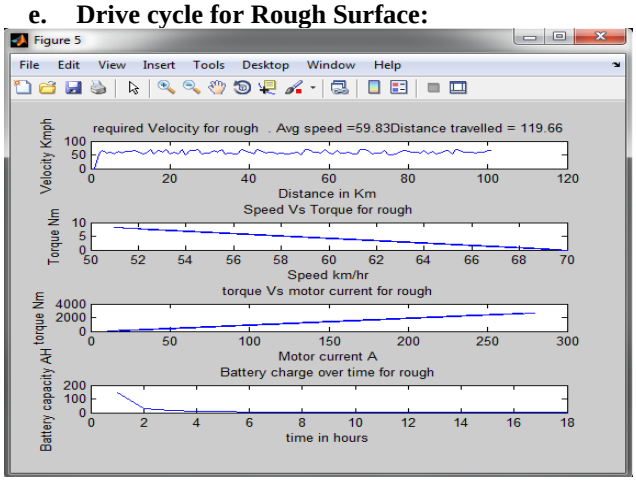
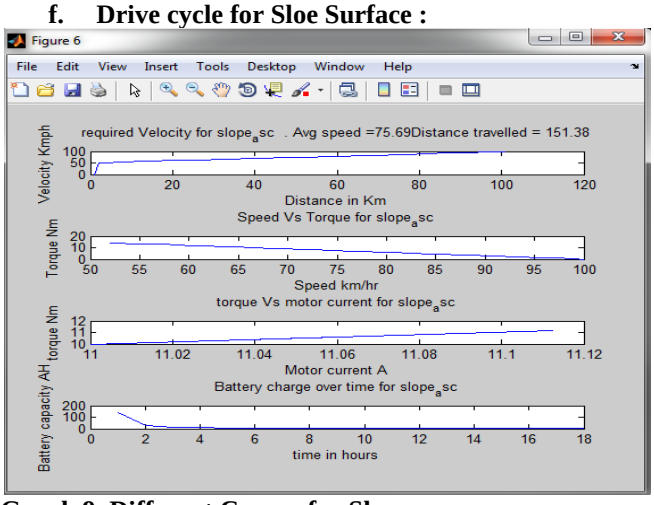


Figure.8. Different Curves for Rough Surface

From the fig7 it is observed that for 2 hrs average speed is 59Km and distance travel is 119.66km/hr. If the vehicle speed is increased from 50 to 70km/hr then torque is low. For the same condition the motor current is 270A then the torque is 3000Nm.

f. Drive cycle for Sloe Surface :



Graph.9. Different Curves for Slope

From the fig7 it is observed that for 2 hrs average speeds are 75.69Km and distance travel is 151.38km/hr. If the vehicle speed is increased from 50 to 100km/hr then torque is low. For the same condition the motor current is 11.11A then the torque is 11Nm.

IV. CONCLUSION

Energy management system is very important for the vehicle. Many countries are adopting green machine concept in automotive sectors. Electrical Vehicle plays important role to saves the nonrenewable sources such as petrol, diesel. Batteries are easily charged using the solar panel as well as power supply. The performance of EV is evaluated using various drive cycles (Flat, Rough & slop) and these drive cycles are analyzed on Matlab.

V. REFERENCES

[1].Ilya Kavalchuk, Huy Le Nguyen, Thanh Pham, Alex Stojcevski, "Methodology of Intelligent Energy Management System Simulation for Electric Vehicle Applications with Asynchronous Logic Controller," 2016 IEEE 7th International Conference on Intelligent Systems, Modelling and Simulation.

[2].Shivani Jain, Neha Tiwari, "Grid Solar Hybrid Speed Controller for Electric Vehicle – A Working Model," International Journal of Scientific Engineering and Research (IJSER) ISSN (Online): 2347-3878 Volume 3 Issue 1, January 2015.

[3].Amit Kumar Singh, Ankit Dalal, Praveen Kumar, "Analysis of Induction Motor for Electric Vehicle Application Based on Drive Cycle Analysis," 2014 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES).

[4].Balamurugan. T, Manoharan.S, "Optimal Design and Control of Solar/Electric/educed fuel consumption(IC engine) Hybrid Powered Vehicle (SEFPHV) technology," International Journal of Renewable Energy Technology Research Vol. 2, No. 5, May 2013, PP: 151 - 169, ISSN: 2325-3924 (Online).

[5].Bambang Sri Kaloko, Soebagio, Mauridhi Hery Purnomo, "Design and Development of Small Electric Vehicle using MATLAB/Simulink," International Journal of Computer Applications (0975 – 8887) Volume 24– No.6, June 2011.

[6].Matthias Felden, Patrick Bütterling, Peter Jeck, Lutz Eckstein and Kay Hameyer, "Electric Vehicle Drive Trains: From the Specification Sheet to the Drive-Train Concept," 14th International Power Electronics and Motion Control Conference, EPE-PEMC 2010

[7].Yogesh Sunil Wamborikar, Abhay Sinha, "Solar Powered Vehicle," Proceedings of the World Congress on Engineering and Computer Science 2010 Vol II WCECS 2010, October 20-22, 2010, San Francisco, USA.

[8].X.-D. Xue, K. W. E. Cheng, and N. Cheung, "Selection of electric motor drives for electric vehicles," in Power Engineering Conference, 2008. AUPEC '08. Australasian Universities, Dec 2008, pp. 1–6.

[9].S. Williamson, A. Emadi, and K. Rajashekara, "Comprehensive efficiency modeling of electric traction motor drives for hybrid electric vehicle propulsion applications,"

Vehicular Technology, IEEE Transactions on, vol. 56, no. 4, pp. 1561–1572, July 2007.

[10].K. Rahman and M. Ehsani, “Performance analysis of electric motor drives for electric and hybrid electric vehicle applications,” in Power Electronics in Transportation, 1996., IEEE, Oct 1996, pp. 49–56.

[11].Sheldon S. Williamson, Member, IEEE, Ali Emadi, Senior Member, IEEE, and Kaushik Rajashekara," Comprehensive Efficiency Modeling of Electric Traction Motor Drives for Hybrid Electric Vehicle Propulsion Applications, "IEEE Transactions on Vehicular Technology, VOL. 56, NO. 4, JULY 2007.

[12].P. Mishra, S. Saha, and H. Ikkurti, “Selection of propulsion motor and suitable gear ratio for driving electric vehicle on indian city roads,” in Energy Efficient Technologies for Sustainability (ICEETS), 2013 International Conference on, April 2013.

[13].C. Shumei, L. Chen, and S. Liwei, “Study on efficiency calculation model of induction motors for electric vehicles,” in Vehicle Power and Propulsion Conference, 2008. VPPC ’08. IEEE, Sept 2008.