Simulation of electric bike using Scilab Xcos

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Abstract - *Electric vehicles have been gaining attention as an efficient and clean means of transportation. This project focuses on the study of dynamic performance and electric consumption of an electric bike. To stimulate the operation of the electric bike, this study establishes the simulation models including dynamic models of the electric bike components and battery. These simulation models are solved by sci-lab to provide the operating characteristics of vehicle. Each major electric component of the electric powered bike is modeled by Model-Based Design (MBD) method with Sci-lab. Modelling of EV in sci-lab can help in predicting the component size, predict the behaviors of system and component, predict the energy consumption and many more. Initially a simulation is created using a standard drive cycle available (NEDC and WLTP). Basically, a drive cycle is a series of data points representing the speed of a vehicle versus time. Drive cycle are produced by different countries and organizations to assess the performance of a vehicles. The data generated from simulation is very crucial while selecting a motor for the vehicle. After selection of motor battery will be selected and based on their specification and power required by the motor. This simulation model will save time and money by running the analysis without buying the actual component.*

Key Words: **Drive cycle, simulation, analysis, dynamic model…**

1. INTRODUCTION

This project includes development of a high performing powertrain there are several areas that needs to be considered. Within the frame of the project the areas of vehicle dynamics, accumulators and propulsion analysis are included. These areas have their own limitations and problems that require to be solved. To properly assess how powertrain would perform during this event. The model will be developed using Sci-lab Xcos, it will use the outcomes of the vehicle simulation code of the power's motor, torque's motor, and speed's motor. Apart from the performance evaluation obtained from the simulation models, there are some aspects of each proposed solution that should be evaluated qualitatively to have a more comprehensive idea of their potential. These aspects include design complexity and cost. After evaluating all the results for the different viable solutions, the best configuration is chosen, and a preliminary design will be provided. This design will include a fast overview of all the components included of the powertrain. Especially component test of each major electric part that are represented by motor, inverter and battery and assessment of the total electric bike system is very important in developing electric powered bike. Functional test and assessment method about each electric component or total system using non-verified prototype component in real situation has not also probability to face mishap or injury due to fault of the component but also causing lots of losses economically and in time. And it is also impossible to do cyclic test at the same circumstances because test conditions such as driving mode, speed and road condition are changed according to test driver or environmental change.

1.1 Model-based design

Model-Based Design (MBD) may be a mathematical and visual method of addressing problems related to designing complex control, signal processing, and communication systems. it's utilized in many motion controls, industrial equipment, aerospace, and automotive applications, embedded systems, system modeling, state estimations & optimizations, etc.… Model-based design may be a methodology applied in designing embedded software.

2. MODELLING AND ANALYSIS

2.1 Chassis

The chassis contains all the calculations related to vehicle dynamics.

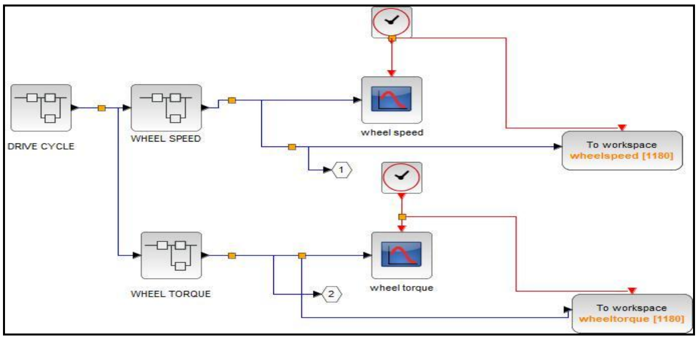

Fig -1: Xcos model of chassis model

2.1.1 Wheel Speed

$$Nw = \frac{V*60}{2*pi*Rw}$$

Where,

Nw = Wheel Speed (rpm) , V = Vehicle Speed (mps), Rw = Radius of rear wheel

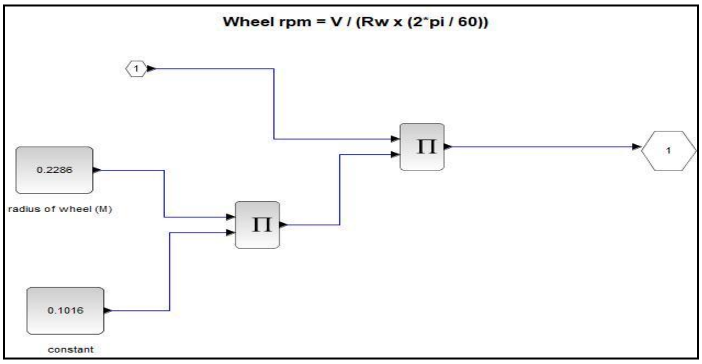

Fig -2: Xcos model of wheel speed

2.1.2 Wheel torque

WT = Total tractive effort * R_W

Total tractive effort = Rolling resistance + Gradient force + Aerodynamic force + Acceleration force

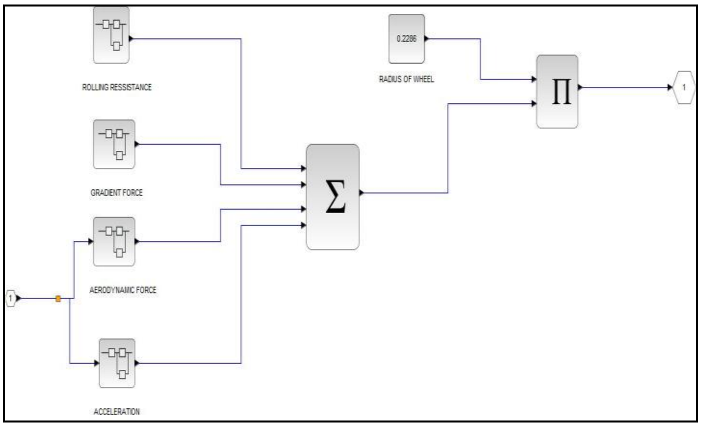

Fig -3: Xcos model of wheel torque

2.1.3 Rolling resistance force

Rolling resistance, sometimes is generally referred to as rolling friction or rolling drag, is that the force resisting the motion when a body (such as a ball, tire, or wheel) rolls on a surface. Rolling resistance force is that the product of gross vehicle weight and therefore the rolling resistance coefficient. The coefficient of rolling resistance, which has the dimension of length, is approximately adequate to the worth of the rolling resistance force times the radius of the wheel divided by the wheel load. The coefficient rolling resistance value depends on the wheels and road material.

Fr = GVW ∗ Crf

Where,

Fr = Rolling resistance force [N]

GVW = Gross vehicle weight [N]

Crf = coefficient of rolling friction

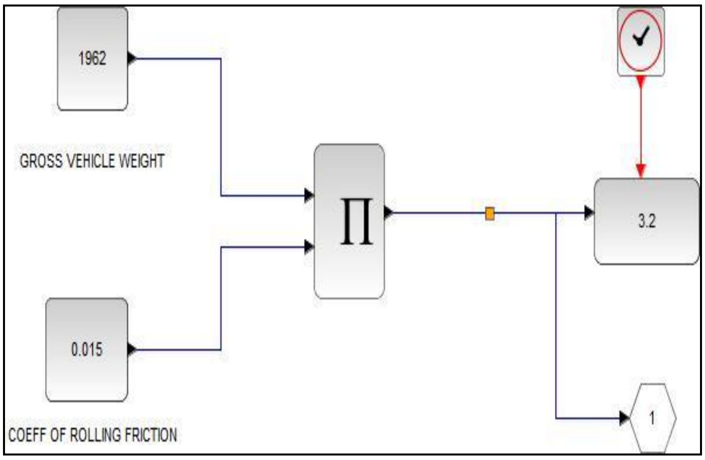

Fig -4: Xcos model of rolling resistance

2.1.4 Aerodynamic force

It is a resistive force acting on the vehicle, because of its frontal area, density of air, geometry of car & cars velocity. When the area of the vehicle is not given the aerodynamic force can be calculated by process called coast down process.

Fa = 1∗rho∗A∗Cd∗⍰2 2

Where,

Fa = Aerodynamic Force [N] ,

rho = Density of air [Kg/m^3] ,

A = Frontal area [m2]

Cd = Coefficient of Drag,

v = Vehicle Speed [m/s]

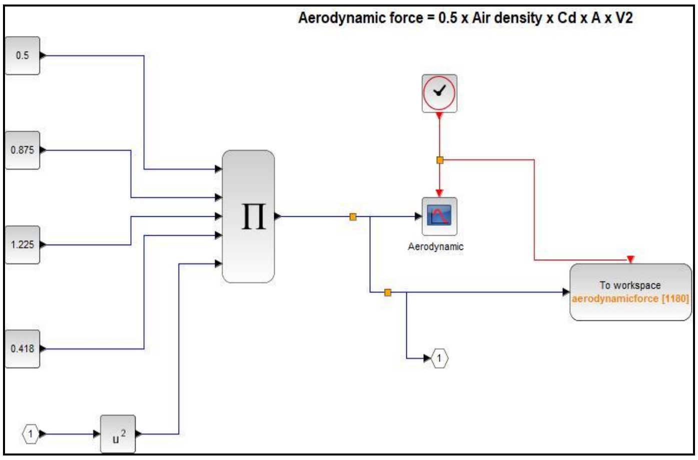

Fig -5: Xcos model aerodynamic force

2.1.5 Acceleration force

Acceleration force is the force that helps the vehicle to accelerate a predefined speed from rest in a specified period of time.

Facc = GVM*a

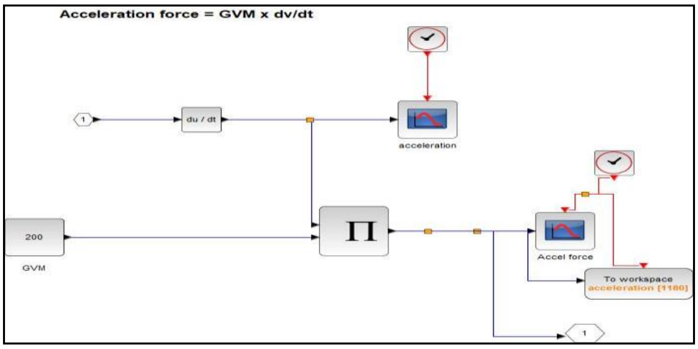

Fig -6: Xcos model of acceleration force

2.2 Transmission

Transmission may be a device present within the electric vehicle which is employed to extend torque or speed at the. wheel. The transmission is connected between the motor and therefore the wheels. Transmission may be a system which transfer power from motor to wheel. An electrical vehicle doesn't have a multi-gear system as in combustion vehicle. Almost all electric vehicle features a single speed transmission which is big advantage considering the load and efficiency loss. This distinction of transmission between electric vehicle and combustion vehicle is majorly due to two reasons. First, an electrical motor can deliver its maximum torque at zero RPM, so it doesn't got to change gear ratios to urge the specified torque. Also, electric motors have a bigger speed range compared to typical internal engine. This means an electrical vehicle can work on one gear ratio throughout the run.

2.2.1 Motor torque

$$M_t = \frac{Tw}{Net\ gear\ reduction * Neff}$$

Where,

Mt = Motor Torque [Nm],

Tw = Wheel Torque [Nm]

Neff = Transmission efficiency

2.2.2 Motor speed

Ms = Nw * Net gear reduction

Where,

Ms = Motor Speed [rpm]

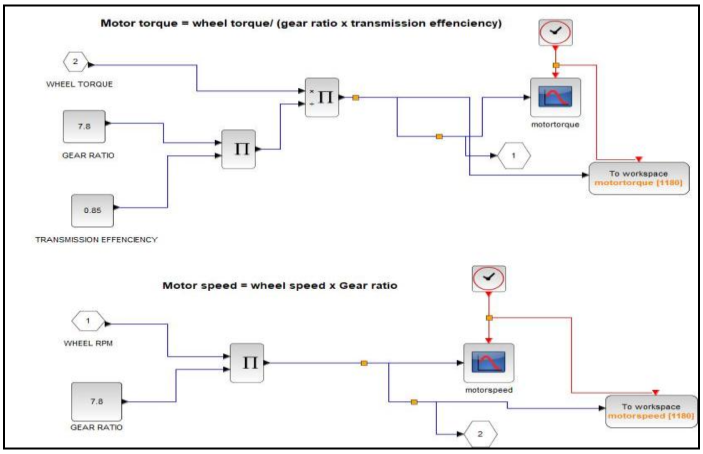

Fig -7: Xcos model of motor torque and motor power

2.2.3 Electric motor

An electric motor is an electro-mechanical device that converts electrical energy into mechanical power.

Motor useful power = $\frac{2*pi*Mt*Ms}{60}$

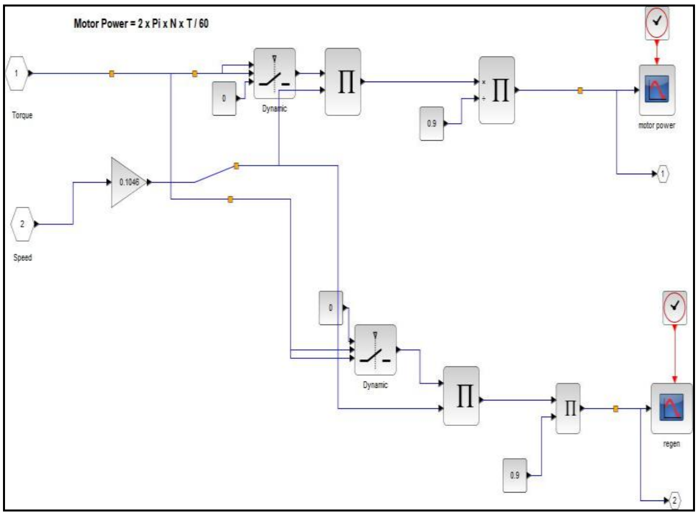

Fig -8: Xcos model of motor power

2.3 Battery

The battery subsystem contains all the required calculations related to the battery.

2.3.1 Battery C-rate

C-rate is a measure of the rate at which that a battery is being discharged relative to its maximum capacity. For example, battery with a capacity of Ah, this equates to a discharge current of Amps. The C rate for this battery would discharge the battery at 500 Amps and C/2 rate would discharge at 50 Amps.

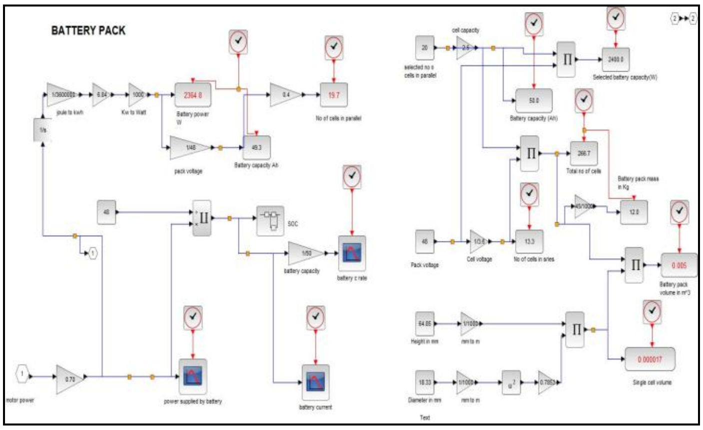

Fig -9: Xcos model of battery pack

2.3.2 State of charge

State of Charge (SOC) of a cell denotes the capacity that is currently available as a function of rated capacity. The unit of SOC is percentage. The value of SOC varies between 0% to 100%. If the SOC is 100%, then the cell is said to be fully charged, whereas a SOC of 0% indicates the cell is completely discharged. The state of charge of a battery can be calculated by taking under consideration the quantity of electrical current which is going in and out of the battery. Below is a methodology recognize as coulomb counting that works on the amount of current entering in to and out of the battery.

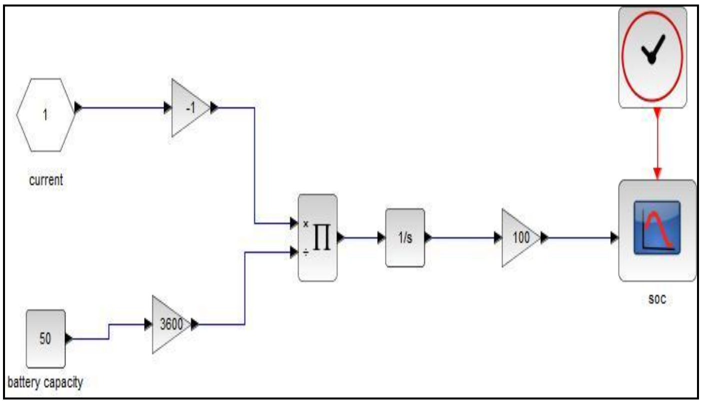

Fig -10: Xcos model of state of charge (SOC)

2.4 Range of EV

Range of an electric vehicle refers to the distance an electric vehicle can travel before the battery needs to be recharged. Range of an EV is calculated by dividing the amount of power in battery (KWh) by the efficiency of the vehicle in (KWh/mile).

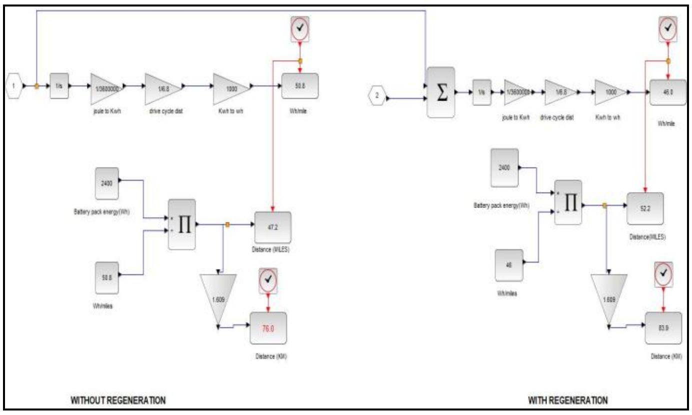

Fig -11: Xcos model of vehicle range

3. INPUT PARAMETERS

Table -1: Input Vehicle specifications

Sl .No	Specification	Value	Units
1.	Kerb mass of vehicle	200	Kg
2.	Driver mass	70	Kg
3.	Gravity	9.81	m/s
4.	Gear ratio	7.8 : 1	
5.	Efficiency of transmission	85	
6.	Front wheel size (dia)	21	m
7.	Rear wheel size (dia)	17	m
8.	Frontal area	0.418	m2
9.	Air density	0.875	Kg/m3
10.	Coeff of drag	1.225	

3.1 Drive cycle

A drive cycle is series of data points representing the speed of a vehicle versus time. Drive cycles are produced by different countries and organizations to access the performance of vehicle in various ways, as instance electric vehicle autonomy and fuel consumption. To perform simulation National European drive cycle (NEDC) is included as reference

Table -1: Drive cycle

	NEDC
Distance	11023 m
Duration	1180 s
Average speed	9.33 mps

4. RESULT

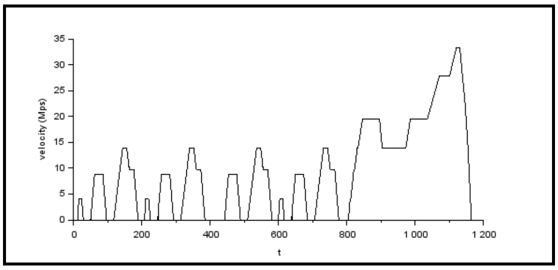

Chart -1: Velocity

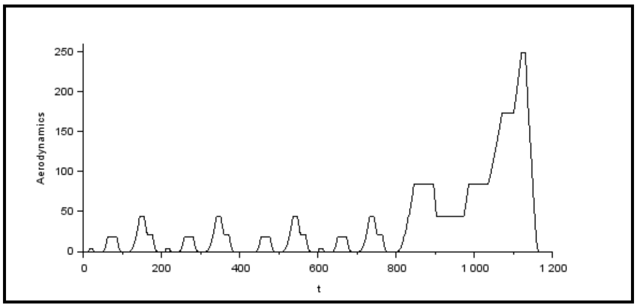

Chart -2: Aerodynamic force

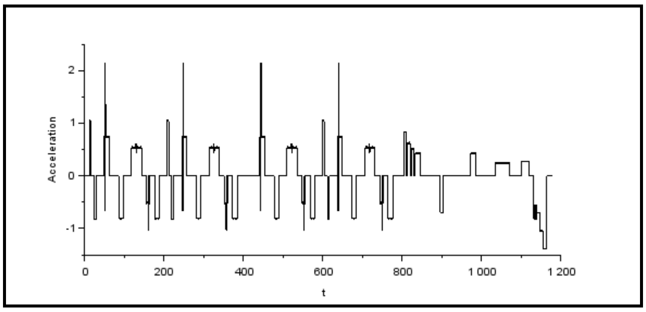

Chart -3: Acceleration force

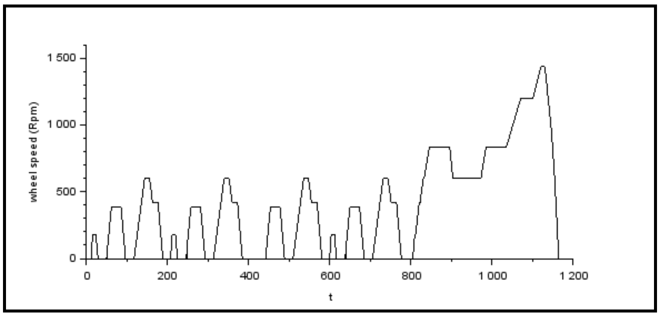

Chart -4: Wheel speed

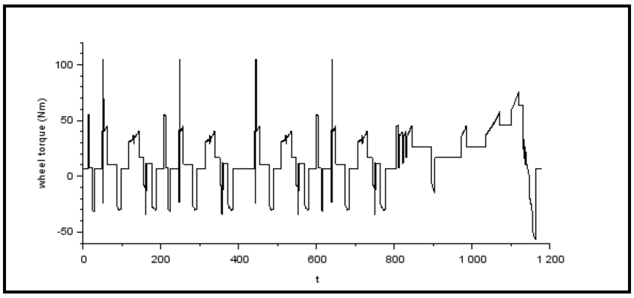

Chart -5: Wheel torque

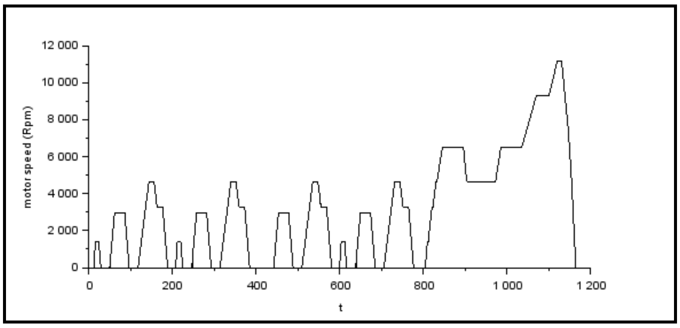

Chart -6: Motor speed

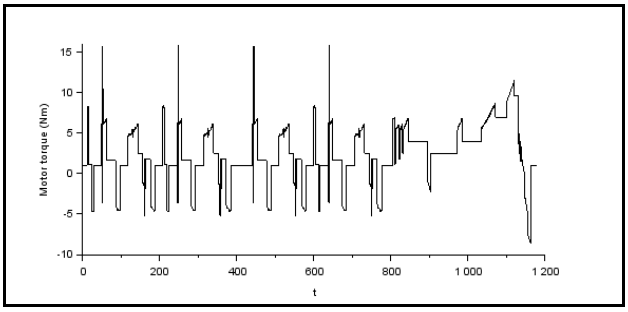

Chart -7: Motor torque

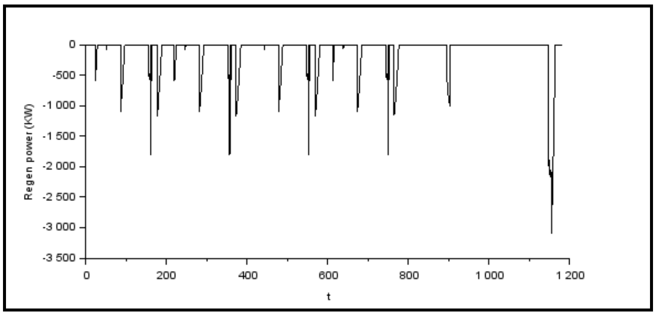

Chart -8: Regenerative power

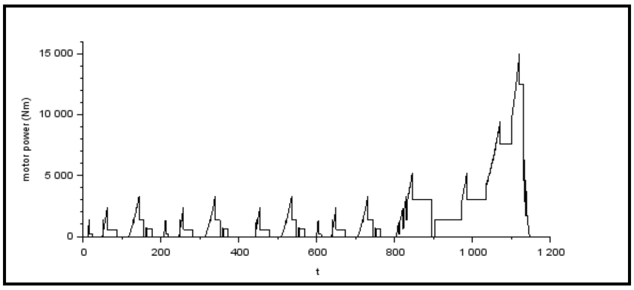

Chart -9: motor power

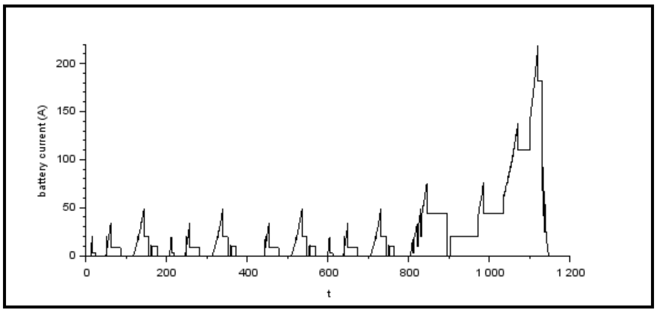

Chart -10: Battery current

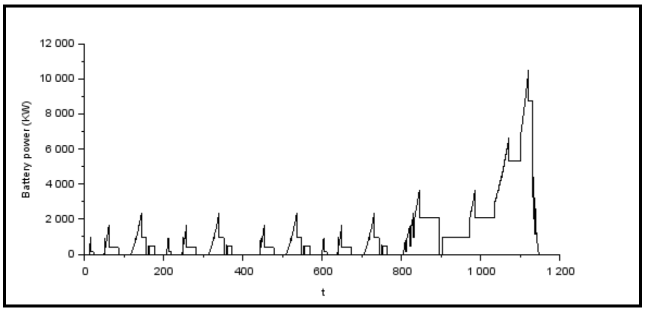

Chart -11: Battery power

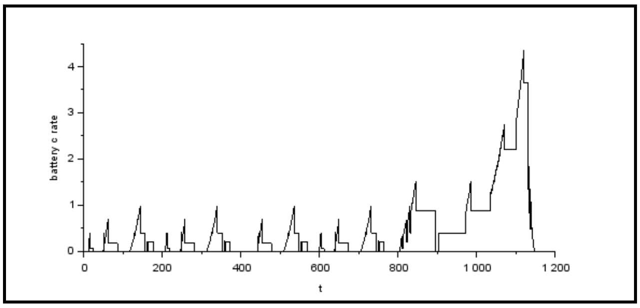

Chart -12: Battery c-rate

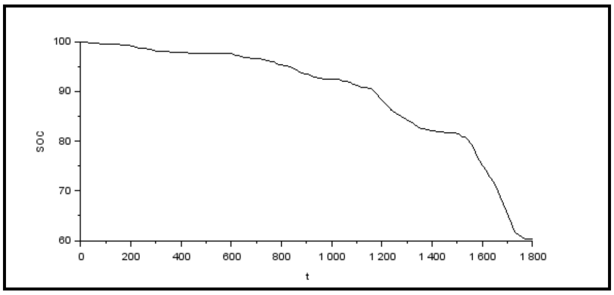

Chart -13: State of charge

5. CONCLUSIONS

In this project, we successfully did the simulation of 2-wheeler electric vehicle using Sci-lab. We selected a suitable motor and designed a relevant battery pack using data of drive cycle which is validated using Sci-lab model. The Battery pack design is also appropriate as SOC is decreasing to around 15% in NEDC. Every simulation has some limitation which might cause inaccuracy compared to real time results obtained from vehicle. However, these simulations are beneficial for selection of components using comparative study based on performance of electric-bike as done in this project.

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