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Simulation and Experimental Analysis of Battery Types for Light Electric Vehicle

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Abstract: *Now-a-days it can be seen that most of people are focusing on cycling for exercising and short distance travelling due to unhygienic lifestyles and increase in environmental pollution and its harmful effect on human. Looking at such circumstances this paper is focused on to generate electrical energy produced by the person via paddling and later consume the same energy for automatic running of the cycle. The demand for Electric Bikes is growing throughout the world due its characteristics of zero emission effects and longer life cycle. An electric bicycle uses electric motors for the purpose of moving which run on different types of Batteries. These batteries undergo many charging and recharging cycles in running conditions. By use of various non-conventional energy sources various batteries worked as energy storage units can be charged which will reduce the required amount of external energy for charging the batteries which will also reduce the use of fossil fuels and also will help to reduce the environmental pollution. The theme of paper is comprised in two sections, in first part a paddling mechanism is proposed which will do the energy conversion from mechanical to electrical and in later part the stored electrical energy is converted into mechanical energy to run cycle on charged batteries. A comparative analysis is also proposed for different batteries to find out efficient types in terms of economic aspects such as cost, thermal runaway, etc. in this work an electric generation mechanism by paddling the cycle is proposed for specified amount of time and based on that the generated electricity is calculated to be stored in battery for charging. Further the simulation results using MATLAB/Simulink has been analyzed for the proposed electric bicycle with different types of batteries, to study the various characteristics of the proposed set up with variation of battery parameters and distance covered by the cycle.*

Keywords: Self charging electric cycle, Simulink, Paddling, lithium ion batteries, lead acid batteries

I. INTRODUCTION

The Electric Vehicle was firstly built in the early 19th century between 1832 and 1839, by Robert Anderson. He also created the first crude electric carriage. Later in 1895, after that an electric tricycle was built by A.L. Ryker and William Morrison manufactured a six passenger wagon. There was a decline in use and production of the electric vehicle in the 1920s. The major causes of the decline in production were: a better road system, decline in prices of gasoline due to the discovery of the Texas crude oil, electric starter were invented, and the bulk production of the internal combustion engine vehicles. The Electric Vehicle consists of an electric motor and it is powered by rechargeable batteries instead of a gasoline cylinder. There are various type of batteries which can be used for propelling the electric vehicle .But these batteries can also increase the weight of the vehicle. From outside the design of all the vehicles is same weather it is electrical or other vehicles. An Electric bike can also be identified as a silent vehicle that does not make noise and prevents noise pollution. Electric bikes are classified according to the power that their electric motor can deliver and the control system that is when and how the power from the motor is applied.

1.1 Problem Definition

The main theme of this work the is conversion of mechanical energy into electrical energy by means of paddling of cycle and storing the energy in suitable storage unit and further it will be used for running e-cycle using stored electrical energy for a short distance. This will help in two ways, first for exercise of the person while paddling and second the

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converted energy which may be lost to environment will be used to charge the battery which will be helpful to run the bicycle for a short distance travelling.

1.2 Objectives

1. Evaluation of work done earlier through related literatures and research work to finalize the proposed idea for light electric vehicle.
2. Evaluation of energy conversion mechanism parameters and applied components to get maximum energy to be stored for battery charging through paddling of bicycle.
3. Design of proposed set up using MATLAB / Simulink to simulate the results of battery performance.
4. Comparative analysis of different battery types using the same Simulink circuit for finalizing the effective types of battery to be useful for the proposed work.

1.3 Scope

The designed bicycle can be used to travel certain amount of short distances and due to its optimized weight it would be easy to carry the bicycle from one location to other location. Also the comparison of both the batteries would give the difference in costs and working of the bicycle with the use of respective battery. It would be a good mode of transport for shorter distances as it would save excessive use of fossil fuels used which will help in conserving our environment.

II. LITERATURE SURVEY

Table 1: Summery of literature

Sr. No.	Name of Author	Work Done	Future Scope
1	Markus Lutz et.al.2011	Design and development of electric vehicle and its advantages	next work in force in electrical mobility and electrical vehicle
2	MD. Rezwanul et.al. 2011	Pedal powered generator used for power generation	Modification in vehicle design for smooth working of vehicle
3	Rajesh K. M., et.al. 2012	Generation of power with the help of bicycle paddling	Alternate resource for non renewable source of energy
4	M. Jawahar , et.al. 2014	Design and construction of pedal operated water pump	Hybrid storage of energy which can increase the machine efficiency
5	B.Sneha, et.al. 2015	Easy way of generating power at small levels	Use of Renewable sources for electricity generation
6	Gicky Jose M.et.al. 2015	Design and Development in bicycle	Adjustment of gears as per trials and increase in safety of rider
7	Mitesh D. et.al. 2016	Self-rechargeable ev bicycle which can be used of propulsion	The design of ev bicycle can be done by self-weight into consideration
8	Hampus E. et.al. 2016	literature on parameters are associated with bicycle planning	Evolution inimplemented factors for Bicycle design
9	Hardik K., et.al. 2016	Comparison of Lithium- ion and Lead-Acid batteries	classification and selection of batteries for various purposes such as E-vehicles
10	C Iclodean1, et.al. 2017	Comparison of various batteries for E-Bicycle	Comparison of batteries and studying its advantages for future use
11	Chien-Cheng Lin, et.al. 2017	Development And optimization of frames of bicycles	decrease the self-weight of vehicle and implementing transportation
12	S Manish et.al. 2018	human powers and alternative energy source is investigated	Replacement to non-renewable energy resources
13	Akshay N. hakole,et.al2019.	Generation of electricity using Dynamo	Use of Renewable sources for electricity generation
14	Rupesh H. Patil,et.al., 2019	Development in fabrication for E-Bicycle	Implementation in bicycle using electric as well as solar energy
15	TinaNielsen et.al. 2020	Recreation conflict focused on emerging E-Bike technology	Restrictions ,limits and regulation for sustainability of E- Bike trials

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III. DESIGN AND SIMULATION

3.1 Design Calculations for Energy Recovery Mechanism

Assuming, Weight of bicycle = 20 Kg and Weight of person sitting on bicycle =80 Kg So,

- Total weight =100 Kg
- Wheel size of bicycle = 622mm=0.622m i.e. radius = 0.311m
- Length of bicycle = 6 ft. =1828mm= 1.828m
- Rolling friction = 0.01 and Coefficient of drag= 0.88 Assuming expected speed of our bicycle = 25Km/hr. Width of bicycle = 2 ft. = 609mm =0.609 m
- Area = length of bicycle × width = 1.828 × 0.609 = 1.1132 mm²
- Speed = 25 Km/hr.

Considering approximately paddling of 2 hours.

- Velocity = 25000/3600 =6.94 m/s
- Total Power required
  = [mass × acceleration due to gravity× velocity× rolling friction] + [air density× coefficient of drag× area× velocity³]
  = [100×9.8× 6.94× 0.01] + [0.6465× 0.88× 1.113× 6.94³]
  = 68.012 + 211.66 =279.672 W.

Table 2: Battery Parameters Comparison

Sr. No.	Parameters	Lithium ion battery	Lead Acid Battery
1	Weight	Light in weight	3times weight of li-on battery
2	Resilience/ discharge	Less vulnerable to high discharge and climate change	Damages through excessive discharge and extreme temperature
3	Life	Excellent	Good
4	Efficiency	High	Low
5	Replacement	6-7years	1.5-2years
6	Cost	Very High	Average
7	Power density	125W/Kg	40W/kg
8	Usable Energy	80%	50%
9	Voltage per cell	3.2V	2V
10	Maintenance	Basic annual Maintenance	Regular Maintenance every 3months

Table 3: Characteristics of different energy storage devices

Type	Energy Efficiency (%)	Energy Density(Wh/kg	Power Density(W/kg)	Cycle life(Cycles)	Self-Discharge Rate
Lead-Acid	70-80	20-35	25	200-2000	Low
Ni-Cd	60-90	40-60	14-180	500-2000	Low
Ni-MH	50-80	60-80	220	<3000	High
Li-ion	70-85	100-200	360	500-2000	Medium
Li-polymer	70	200	250-1000	>1200	Medium
Flywheel	95	May-30	1000	>20000	Very High

Table 4: List of Parameters required for Simulation using Matlab / Simulink

Battery Parameters	Nominal voltage	48 V
	Rated capacity	100 ah
	Initial stage of charge	100%
Vehicle parameters	Mass	100kg
	No of wheels per axle	2
	Horizontal Distance from CG to front axle	0.7m

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	Horizontal Distance from CG to rear axle	0.7m
	CG height above ground	0.5m
	Gravitational Acceleration	9.81m/s^2
	Drag coefficient	2
	Air Density	1.18 kg/m^3
Gear, differential and motor parameters	Carrier to drive shaft teeth ratio	4
	Follower to base teeth ratio	2
	Inductance	12e^{-6} H
	No Load speed	2000 rpm
	Rated speed	1800 rpm
	Rated Load	5 kW
	Rated DC supply	50 V

Simulation: (Time of simulation study for 1000 seconds)

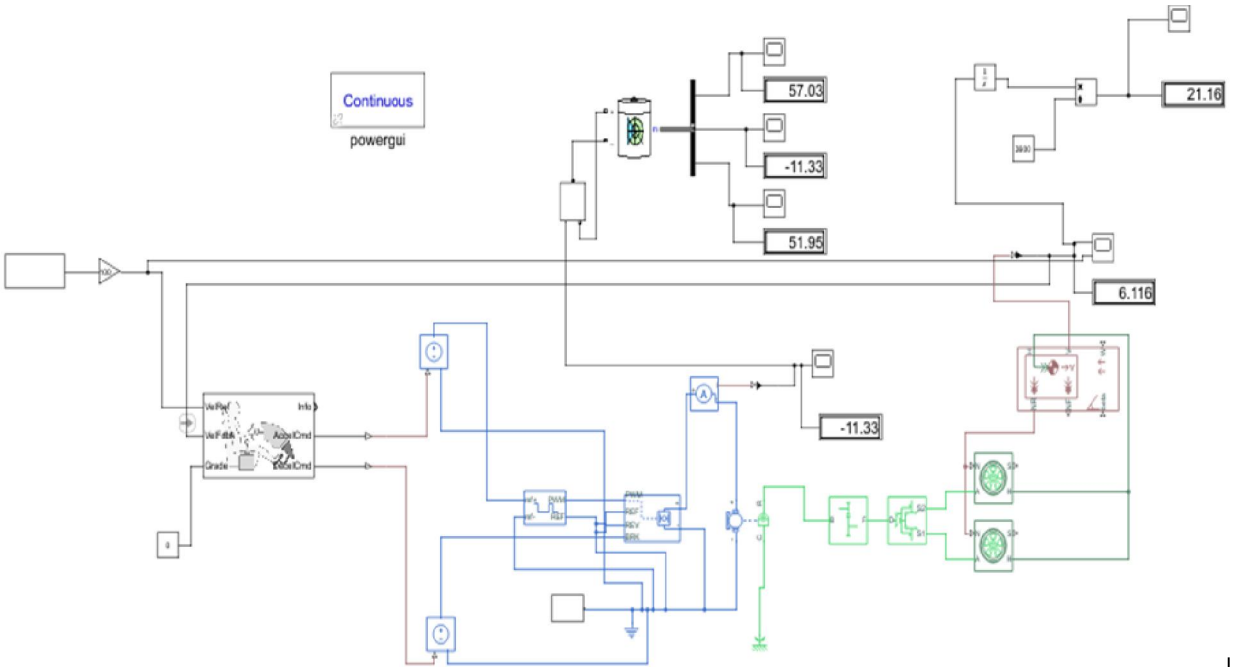

Figure 1: Simulink model of E-Bicycle using Matlab / Simulink

Simulation Results with lithium Ion Battery

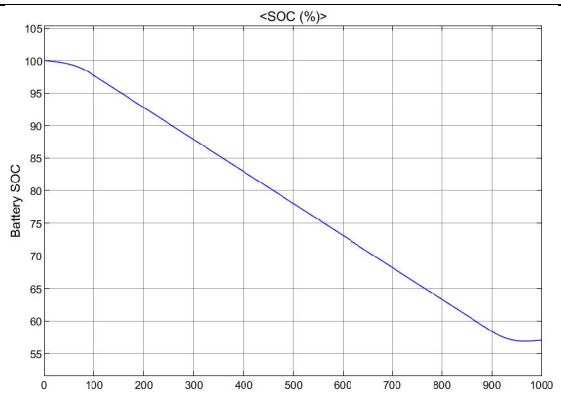

Figure 2: Variation of Battery State of charge

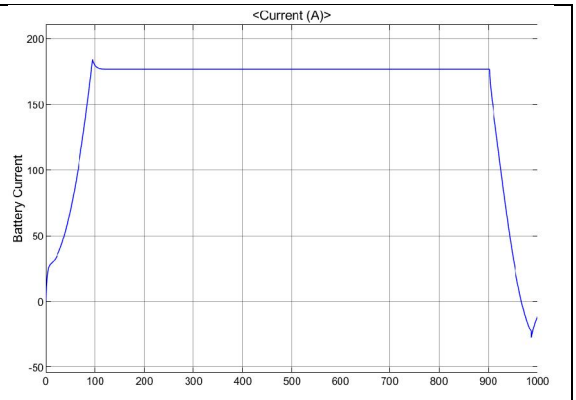

Figure 3: Variation of Battery Current

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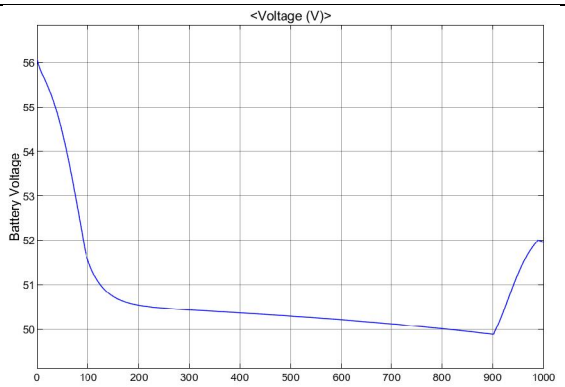

Figure 4: Variation of Battery Voltage

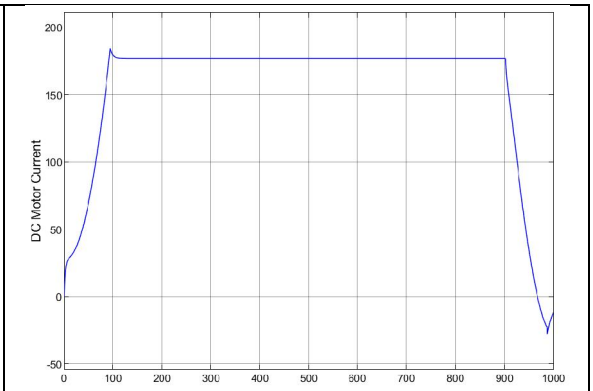

Figure 5: Variation of Battery Voltage

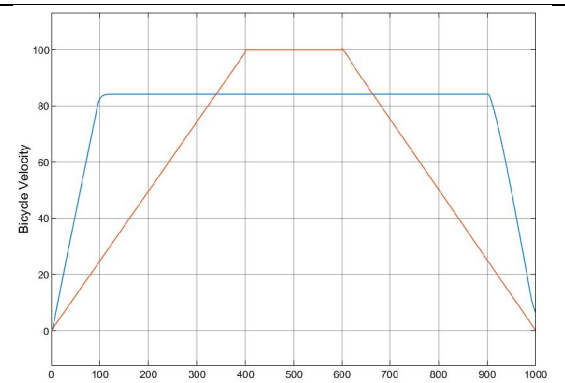

Figure 6: Variation of Battery Voltage

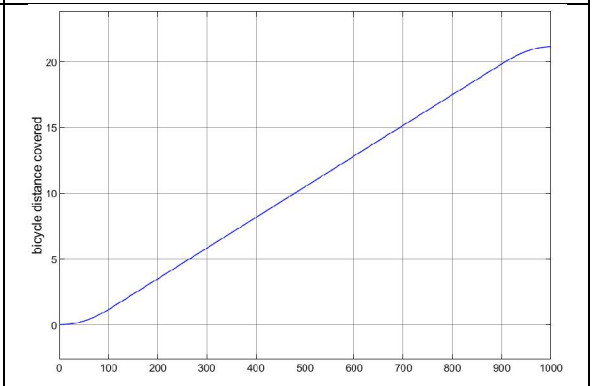

Figure 7: Variation of Battery Voltage

Similar simulation is performed using different types of batteries and results are summarized below,

Table 5: Simulation results of different batteries for performance parameters

Types of Battery	SOC in %	Current in A	Voltage in V	Velocity in Km/hr	Distance in Km
Li-ion	59.97	-5.679	51.91	3.063	20.11
Lead acid	61.57	-5.687	50.57	3.068	20.11
Nickel Cadmium	64.78	-5.679	51.39	3.063	20.11
Nickel metal hydride	62.83	5.679	52.08	3.063	20.11

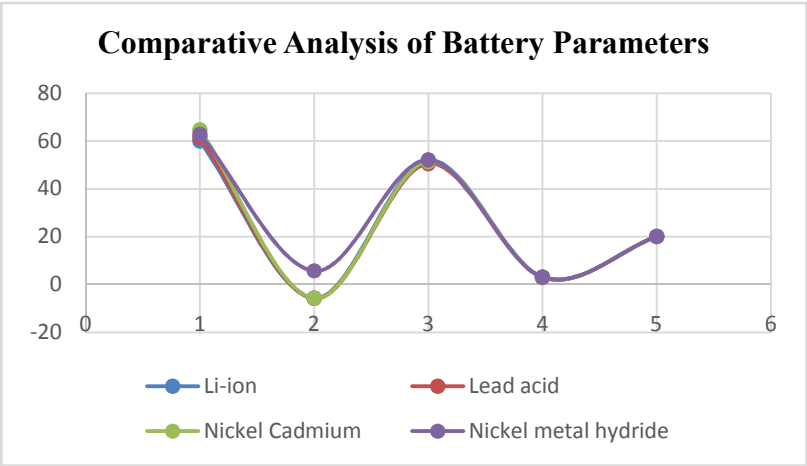

Figure 8: Comparative analysis of different battery parameters

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Experimental Analysis:

Motor Specification

- Type: Brushless DC Motor 12watt.
- 12 V, 5000 Rpm Capacity

Battery Pack Calculation

Calculations of battery pack for generating approx. 100 watt energy for approx. 2 hours.

- Single battery with 3.7 V and 2500mAh capacity.
- Using formulae (assuming 80% efficiency of the battery)

$$\text{time(t)} = \frac{\text{Efficiency} \times \text{Battery voltage} \times \text{Battery capacity}}{\text{Total required power}} = \frac{0.8 \times 11.1 \times 20}{100} = 1.776 \cong 2\text{Hours}$$

- Therefore we need 24 cell of batteries with a pack of three (3.7 x 3 = 11.1) pairs in parallel and eight (2500mAh x 8 = 20Ah) in series combination.

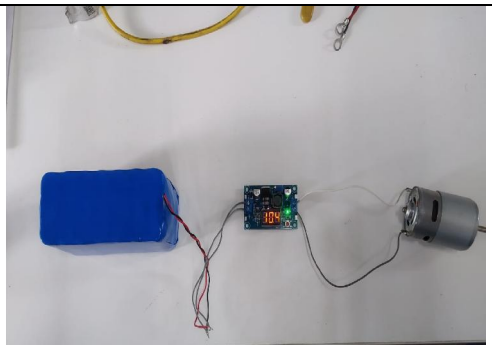

Figure 9: Battery discharging

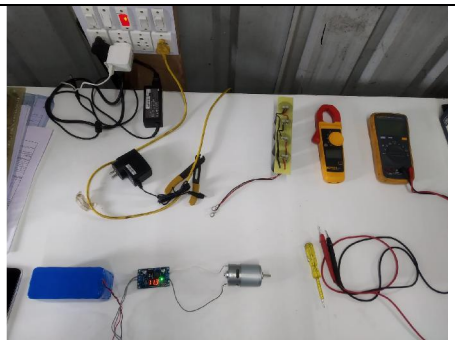

Figure 10: Battery discharging

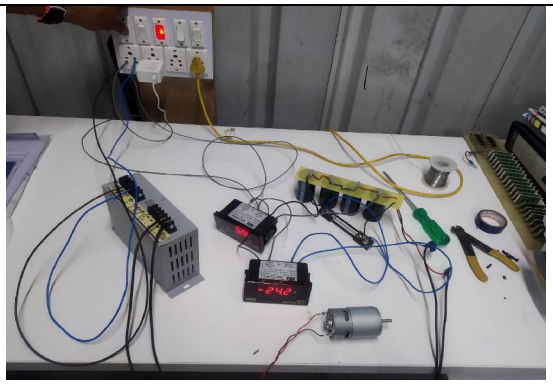

Figure 11: Supercapacitor charging

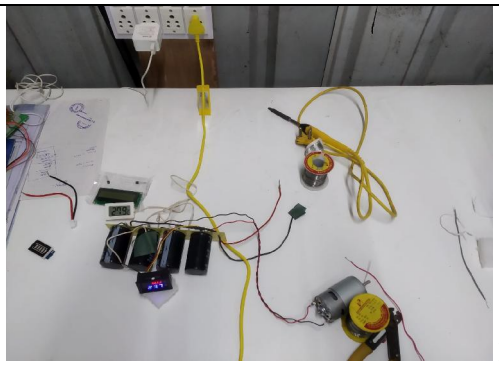

Figure 12: Supercapacitor dis-charging

IV. RESULTS AND DISCUSSION

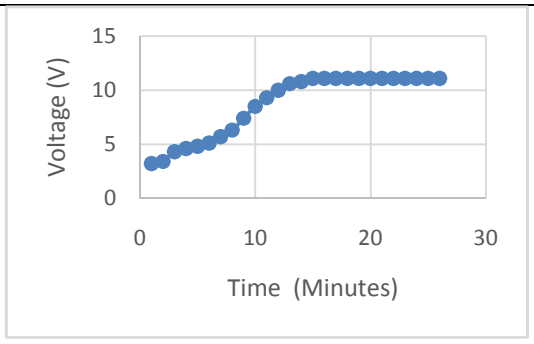

Figure 13: Voltage vs time graph

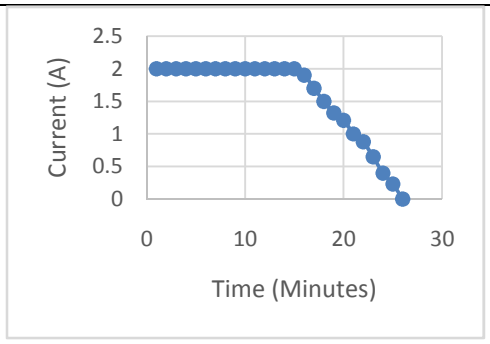

Figure 14: Current vs time graph

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V. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

1. Significant work has been done on battery and supercapaciter charging and discharging characteristics of battery and supercapaciter by many researchers but very little work has been done on its hybridization considering all efficiency characteristics.
2. The calculation for energy recovery mechanism for the proposed set found that approximately = 313.678 W of energy can be recovered by paddling for approximately 2 hours.
3. The Simulink analysis shows different graphical results such as State of Charge (SOC), Voltage, Current, Velocity, and Displacement using Lithium-Ion Battery as an energy sources for running the bicycle which indicates approximately 59.97 state of charge of battery which was initially charged 100 %, velocity of bicycle for 1000 seconds is 3.063 km/hr. and distance covered is 20.11 km which is near to the target value of the proposed project.
4. Comparative analysis of lithium ion battery with other batteries shows that approximately same velocity and distance achieved with slight difference in state of charge. But if we go to the charging and discharging cycle and other efficient parameters of those batteries, lithium-ion finds the best suited solution for e-mobility.
5. Experiential and simulated results are matched up to acceptable accuracy level as per the comparative graphical analysis. Charging time for battery pack charging and discharging time were in hours i.e. approximately 3 to 4 hours which would be quite significant for running the light weight electric vehicles or similar applications.
6. Much focus needs to give on careful charging and discharging experimental analysis of supercapaciter due to tremendous amount of energy storage with fast charge and discharge characteristics.
7. A light weight structural design of two wheeler / three wheeler is proposed for further application using the hybrid combination of lithium ion battery and supercapaciter.
8. Further nonlinear programming methods have been proposed for parameter estimation of battery and supercapaciter.

5.2 Future Scope

1. Further work can be done for different types of batteries and hybridization of different energy storage systems. i.e. hybrid energy storage systems of IC engine and battery, HESS of LPG and Battery, HESS of battery and supercapaciter, HESS of battery with solar panel, and many more to get efficient solution to meet energy and power density requirements.
2. The work can be implemented for other types of light vehicles of two wheeler or three wheeler as well as for heavy transport vehicle and four wheelers for further getting effective solution for e-mobility and towards reducing the dependency on petroleum fuels and its harmful effects on human beings.

REFERENCES

[1]. Hampus Ekblad, Ase Svensson & Till Koglin , literature of how different parameters are associated with bicycle planning.
[2]. Gicky Jose Malppan, Tom Sunny Aug, Design and Development in bicycle.
[3]. Akshay N. Chakole, Vishal A. Dhotre, P. V. Raut , Generation of electricity using Dynamo.
[4]. Rajesh Kannan Megalingam, Pranav Sreedharan Veliyara, Raghavendra Murali Prabhu, Rocky Katoch 2012 Generation of power with the help of bicycle paddling.
[5]. Chien-Cheng Lin, Song-Jeng Huang, Chi-Chia Liu 2017 Development and optimization of frames of bicycles.
[6]. Rupesh H. Patil, Mrunalini E. Raut , Harshada R. Zunjarrao, Ashish B. Padwal Feb,2019 Development in fabrication for E Bicycle.
[7]. Tina Nielsen Sadie Mae Palmatier Abraham Proffitt Recreation conflict focused on emerging E-Bike technology.
[8]. Hardik Keshan, Jesse Thornburg and Taha Selim Ustun Jan,2016 Comparison of Lithium-ion and Lead-Acid

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batteries.

[9]. C Iclodean1, B Varga, N Burnete, D Cimerdean, B Jurchias 2017 Comparison of various batteries for E-Bicycle.

[10]. S Manish Yadav, Ajey Kumar Thakur, Mohd. Adil, Rahul kumar Arun Naithani. Dhruv Kumar, Ashutosh April, 2018 Importance of human powers and alternative energy source is investigated.

[11]. Md. Rezwanul Kabir, Mohammad Ashabul Haque, Tawsif Rahman Dec, 2011 Pedal powered generator used for power generation.

[12]. B.Sneha , Dr.M.Damodar Reddy Oct,2015 Easy way of generating power at small levels..

[13]. M. Jawahar , G. Venkanna , B. Sandeep Dec,2014 Design and construction of pedal operated water pump.

[14]. Markus Lutz 2011 Design and development of electric vehicle and its advantages.

[15]. Mitesh Dodiya, Ashish Modi, Sandip Mokariya, Nishan Panchal 2015-2016 Self rechargeable electric folding bicycle which can be used of propulsion.

[16]. R.S Jadoun & Sushil Kumar Choudhary May,2020 Explore the acceleration and speed of electric powered bicycles.

[17]. MD Saquib Gadkari, Khemchand Kolte, Mrunal Jasani, Akash Vichare, Beatrice 2014 Method of generating power by ceiling fan and storage of energy in battery.