Design Approach of Regenerative System for an Electric Bike Using Alternator

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Regenerative system for an E-bike is a progressive approach for regenerates the power of an electric bike, by the aid of an alternator with the intension of protecting the environment and supplant the need of fuel because of its depletion and immoderate amounts of carbon emission in the atmosphere leads to severe pollution. Moreover, when the bike is riding charging of battery is getting lower as per extent. However, if the distance per charge (say 120Km/charge) is more then waiting for batteries to get its 100 percent charging is a very cumbersome task and also a shear wastage of time . Thus, there is a prior need to develop such environmentally compatible E-bike which could reduce the environment contamination as well as increase the range by the help of regenerative or secondary power source system. Such system enables conversion of mechanical energy into electrical energy. In this action, four parameters has been considered for the sequence, i.e. ,the motor efficiency, reducing charging time of battery, cost analysis and design analysis has studied and a regenerative system for an electric bike has been proposed and that consists of a BLDC (Brushless DC motor), a blonde weight chassis, a controller, an alternator and a lithium ion battery pack will give a better performance and long life of battery with the assist of hybrid battery system. The results shown that speed and torque of the BLDC hub motor has a significant impression on the power propagation via alternator. The speed of the motor is 2900 rpm, 48V and 32amp.

Keywords: Hero Honda Hunk, BLDC, Throttle, Alternator, Led acid battery, Controller

INTRODUCTION

A few financial and natural components are adding to expand enthusiasm for alternative vehicle innovations. The examinations expressed the supplies of non-renewable energy source, for example, coal, flammable gas, and oil are constrained. Furthermore, the fuel costs particularly for petrol are increasing incredibly and is has reached to approximately 75 rs per litre [1]. Likewise, the contamination because of the petrol vehicles in urban communities and urban regions is expanding perpetually. Subsequently, to relieve this issue, flighty methodologies have been grown recently, including electric bicycle transformation, i.e., change of electric power to mechanical power. Karen et al [2] had structured an Electric vehicle in 1999, which consolidated with a traditional internal combustion engine and an equal HEV framework utilizing the simulation package, he introduced a simulation and modeling package at Texas AM College, written in the graphical reproduction tool using MATLAB. Where the outcome has been considered as fuel utilization, carbon outflow and unpredictability are thought about and examined for every one of the vehicles.

Ma Xianmin [3]has invented a novel propulsion system design scheme for Electric Vehicles which require high power density. The numerical models proposed for an electric vehicle dependent on vehicle dynamic qualities. As indicated by the power stream, the entire framework has isolated into seven capacity obstructs, then the models are recreated in MATLAB tool, moreover the results are successfully proven for EV.Nitipong Somchaiwong and Wirot Ponglangka [4] proposed "Regenerative Power Control for Electric Bicycle" comprising of PM brushless dc motor which is inside the wheel establishment. This framework happens because of the regenerative force managing to forestall a DC-connect over-voltage condition. This strategy uses to inspect the energy leftover portion from a motor while a motor was suspended to brake off. This proposes fit for assessment the voltage that provisions to motor and examination with the reflected voltage from the motor.Cuddy and Keith [5] played out an equal and arrangement designed hybrid vehicles likely plausible in the following decade are characterized and assessed utilizing an adaptable Propelled Vehicle Test system (Guide). Fuel economies of two diesel-controlled hybrid vehicles are contrasted with an equivalent innovation diesel powered internal combustion engine. The mileage of the equal crossover characterized is 24 percent superior than the internal combustion engine and 4 percent superior to the series hybrid.

Daniel [6]designed and developed a hybrid electric vehicle. The suggested naming as Hybrid Electric Vehicle Design indicated that it was operating good in electrical mode and leaving the hybrid conversion as a potential development. He did a simulation on PSCAD/EMTDCand validated the simulated results using the hardware. G. Adinarayana, Ch. Ashok

Kumar and M. Ramakrishna [7] deals with a hybrid Petro-electric vehicle with electric start and petrol run. Hybrid vehicle are those type of vehicle which can run with the help of two or more power source. TVS SCOOTY is used for hybrid system, this vehicle embodied by an Internal Combustion Engines, the front wheel motor has been connected to the forks by the arc welding and a power booster which is connected with ultra saver kit to regulate the voltage. And a set of 4 batteries connected in a series kept between seat and engine. Fred Chiou [8] designed a pilot project, solar charging station which has been performed on Weber State University campus. The framework exhibited two new ways, Sustainable power source, and Sunlight based PV frameworks. It is comprising of photovoltaic, solar based board, solar based module, and solar based PV framework. The fundamental essence of this venture is to fabricate a trial solar-powered station to charge the electric bicycles and electric cruiser additionally train the understudy's hands-on understanding of solar based energy applications and create maintainability by using a sustainable power source.

In view of this writing audit, it very well may be presumed that the regenerative framework for an Electric bike surely has incredible potential for future applications. A wide scope of research has been completed to choose distinctive strategy, material and plan of electric bicycle that offers highlight, for example, Solar based energy for Electric Vehicle, Petro-electric Vehicle, Hybrid Electric Vehicle, and Arduino based hybrid power auto cycle, and so forth. Hypothetical work has been done on the course of action of the Regenerative arrangement of an EV and scientific articulations proposed dependent on perfect presumptions. The proposed strategy uses by diminishing the charging time and considers new factors for the plan of a successful force recover framework for an EV. The four components considered in this are the engine productivity, decreasing the charging time of the battery, cost investigation, and plan examination. Information in regards to the elements overseeing the regenerative arrangement of an EV is valuable for the general public and as needs be, appropriate alterations are brought into the proposed framework. Their impacts on the battery charging time and alternator power age are plotted for the proposed framework.

DESIGNING THE REGENERATIVE SYSTEM OF AN E-BIKE In today's modernized world electric bike, bicycles and scooters is rapidly growing in automobile industry. To protect the environment the need for alternative fuel or non-conventional energy is necessary. Most of the electric bike emerging locally are incorporated with a rear wheel BLDC (Brushless DC motor), a blonde weight chassis, a controller and a lead acid battery pack. There has been an issue with battery charging time which is 6 to 8 hrs and also average speed of the E-bike is 20-25km/hr. Considering these drawbacks the author of this paper modifying an existence petrol vehicle which has been incorporated an electric Dc hub motor, a controller and an alternator for generate the electricity.

The following assumptions are considered during the design and analysis:

- Lessen time of charging
- Improved battery life
- High Current Capacity
- High Density of power
- Simple Charging Method
- High Efficiency

The measure of intensity a vehicle needs to go at a given speed can be determined by including the streamlined drag and moving opposition. The recipe for streamlined obstruction is given underneath [9]:

$P_{drag} = 0.5\ \rho\ C_d A V^3$

Where, ρ – Density of air

C_d – Coefficient of drag

A – Frontal area of vehicle in m^2

V – Speed in m/s

And rolling resistance may be calculated as follows:

$P_\pi = VC_\pi g\ m$

Where, V - Speed in m/s

C_{rr} - coefficient of rolling resistance

G - 9.81m/s2

m - Mass (kg)

So, total power required to maintain the vehicle of 320kg speed at 45km/h is about

$P_{drag} = 0.5*(1.225)*(0.8)*(1)*(12.5)^3 = 957W$

$P_{rr} = (12.5)*(0.04)*(9.81)*(320) = 1570W$

Total power required (Pt) = $P_{drag} + P_\pi$

• Pt = 2527W

Speed (rpm) = (m/s) 60/circumference of wheel

Assuming diameter of wheel= 19'' = 482mm=0.482m

$$rpm = (12.5)60/\ 0.482 = 1556$$

$$\text{Torque (Nm)} = 9.55\ (\text{power})/\text{Speed(rpm)}$$

$$= 9.55(2527)/1556$$

$$= 15.50\text{N-m}$$

Depending upon all these considerations 1kW 48V BLDC hub motor is selected.

Figure(a) shows the body of Hero Honda Hunk(150cc) which is used for experimentation setup with design modification above.

Figure(a): Electric Bike Chassis for Experimental Design (Hero Honda Hunk)

Battery Power calculation:

- Motor voltage = 1000W at 48V
- Maximum current drawn from motor = 1000/48 = 20.83A
- Required Runtime (endurance + cross-pad round + acceleration test) = 1.5Hrs+0.5Hrs+0.5Hrs= 2.5Hrs.
- Battery required for Required Runtime = 20.83*2.5
- Total required time= 52.075 A-h
- Total Power of Battery = 52A-h*48V = 2496W-h
- According to motor data sheet to generate 3.09 N-m torque it requires 28 A current which is less than expected.

Energy Calculation:

- Energy consumed by motor in 3 hrs. = Power x Time = 750 x 3 = 2250 WH (assumed that motor consumes 750W power continuously at 40 kmph)
- Energy Stored in battery = Capacity x Voltage = 52 x 48 = 2496 WH (assumed 100% usable battery capacity)

EXPERIMENTAL SETUP AND PROCEDURE

Experiment were performed using a BLDC hub motor, a controller, a set of lithium ion battery and an alternator. The detail and specification of components of this project is given in a tabular form:

COMPONENTS NAME	Components Image	**SPECIFICATIONS**
BLDC motor		Motor Type : Brushless DC Motor(BLDC Motor) Rated DC Voltage (Volts): 48

Lithium ion Battery		Nominal Capacity:3840 Wh Usable Capacity:3744 Wh Charge cut off voltage:54.6V Discharge cut off voltage:41.6V Continous Discharge Current::35A Peak Continous Charge Current:70A. Discharge 10A, 1C Charge 2.6A Battery Pack Dimension(L x W x H): 450mm,300mm,170mm. Battery Weight(in kgs):26.136kgs Discharge over current protection: 70A.
Motor Controller		Over Voltage Cut-off (Volts): 58 Under Voltage Cut-off (Volts): 41 Commutation Angle (Degrees): 120 Rated Power (Watts): 1500 Rated Current (Amperes): 50 Operating Temperature (°C): -20 to 80 Protection Class: IP33 Brake De-energize: High Throttle voltage: 1V to 4.5V Number of Mosfets: 24
ALternator		Type of Product : Alternator Make : Maruti Specifications : 12V, 55A Applications : Alto 800 Petrol
Throttle		Color Black Style striae Round Wire Length 30cm Inside Diameter 2.2cm Size 13 x 3.6cm Temperature -20°C- 80°C Operating voltage 5V Adjustment range Minimum ≤1.0V; highest ≥4.0V Function high, medium and low grades governor

Chain Drive		Type : Ritzel Intended use: hub gears Material Type : steel Build : Single speed No of Gears : 2

Design Procedure:

For our undertaking, we had been chosen a normal motor bicycle of model Hero Honda Hunk(150cc). What we expect is getting a speed of 40KMPH in urban zones with a negligible measure of contamination and furthermore energize the battery simultaneously with the assistance of alternator. To get this prerequisite we are doing some significant changes in a typical petroleum bicycle. The progressions that we have made supplanting the inward Ignition Motor by BLDC center point engine with the intensity of 1000w and 48V.

Hub motor electromagnetic fields are provided to the stationary windings of the motor. The external piece of the engine follows or attempts to follow those fields, turning the connected wheel. In a brushed engine, energy is moved by brushes reaching the pivoting shaft of the motor. Energy is moved in a brushless motor electronically, taking out physical contact among stationary and moving parts. Albeit brushless motor innovation is progressively costly, most are more effective and longer-enduring than brushed motor frameworks.

At starting, we had taken a BLDC hub motor which has only one sprocket but it has not fulfilled our requirement that's why we have coupled another sprocket for alternator on the motor shaft with the help of arc welding.

Figure(b): BLDC hub motor with two sprockets

The main purpose of using two sprockets is one for rear-wheel connection and another for alternator chain connection. Similarly, we have welded the sprocket in Maruti 800 alternator.

A controller is fitted in the available free space of a normal bike battery. The controller connects the power source to the motor it controls the speed and optimizes energy conversion.In this project we have used the lithium ion battery with the power ratings of 48V and 32amp.. The reason behind using this type of battery is getting high energy density and self-

discharge with the low maintenance. By replacing the oil tank of normal bike we have made a slot for the battery. It can be possible with the help of welding.

Figure(c): Double Chain Mechanism

Figure(d): Final assembly of Regenerative E-bike

Coming to the throttle operation, it is totally based on variable speed resistance. In details, the speed will be regulated by using the resistance. The throttle placement in the electric bike is adjusted and placed on the right handle bar by replacing engine throttle.

These are the major changes we have made to fulfil our requirement for the Regenerative system for an Electric bike.

Here we have utilized the additional hotspot for charging the battery to give the capacity to the motor. Since a solitary charge would not be adequate when longer is the range. The square outline of the regenerative framework for Electric bicycle has appeared in the abovementioned. We have used two arrangements of battery, an alternator, a controller and a DC brushless engine whose shaft is combined with two sprockets. One is associated with a back wheel which will assist with turning the haggle one will assist with pivoting the alternator individually. At the point when the bicycle is moving at an intensity of 1000watt, the alternator will likewise pivot which will change over the mechanical vitality into electrical vitality and it will store it the second arrangement of battery. On the off chance that the quick arrangement of batteries has released, we can energize the battery from the second arrangement of batteries with the assistance of a typical switch. For controlling pace we utilized the throttle [10].

FACTOR CONSIDERATION DURING THE DESIGN OF REGENERATIVE SYSTEM OF AN E-BIKE

Motor Efficiency

The bike which is available at present market Incorporated with Internal Combustion Engine which is 40% efficient whereas BLDC hub motors equipped in Electric bike are 90% efficient in power utilizations. The motors are hearty to such an extent that it can use in a wide range of streets and climate conditions.

Longer Charging Time

The battery expects 6 to 8 hours of charging time. It is actually a major issue when you need to sit tight for 6 to 8 hours to get the charge of the battery.

Eco-Friendly

The electric battery is derived from non-conventional sources, so electric bikes are very environment friendly.

Cheaper and Comfortable journey

Electric motorbike is having acceptable proficiency, electric units required to travel a given separation contrasted and non-renewable energy source driven bicycle is excessively less (E-V has a normal of 0.12 cost per unit separation). Electric bicycles are the calmest of all methods transport.

Battery Issues

The battery is the most important component of any electrical vehicle.Tesla, the largest electric games vehicle company, has gone to statistics such as 200km / hr output and an improvement in range of 0-60km / hr in 3.7 seconds.It has just been conceivable because of the decent battery plan. LiFePO4 has a bigger life expectancy and is lighter and cleaner.

RESULT AND DISCUSSIONS

The design we have made in the above section for regenerative system of an EV is used as experimentation platform. The author of this paper would attain following momentous improvement in result for different parameters:

- **Increased Range Per Charge**

The Electric bicycle which is developing locally has a lower run for every charge of around 50 to 70Km/charge. As our plan includes a regenerative framework with the goal that we can accomplish a most extreme scope of 80Km/charge.

- **Increased Speed**

Electric bike which is available in present market has low speed range of 25Km/hr to 35Km/hr. Experiment platform bike has achieve a speed of 45Km/hr with load of two person.

- **Reduction in charging Time**

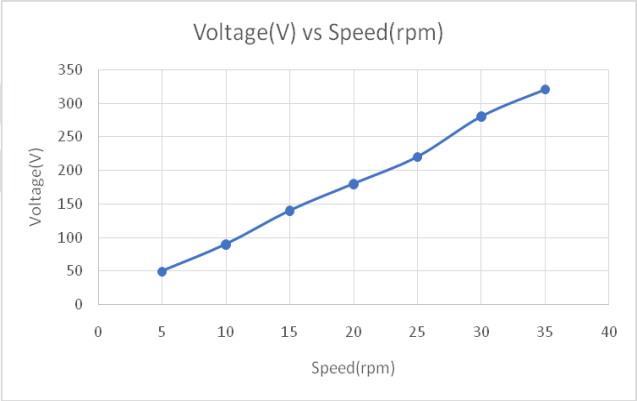
Right now, I have utilized an optional force source which is an alternator so when the bicycle is heading out starting with one spot then onto the next, the alternator or generator is associated right now can charge the battery itself. In this manner, we could state that the charging time has been diminished after one battery has released another battery will get a charge at the hour of running.

Experimentation relationship between voltage supplied to motor and motor speed:

The relationship between voltage supplied to motor and cycle speed shown in table 1:

Voltage(V)	Speed(rpm)
5	50
10	90
15	140
20	180
25	220
30	280
35	320

Table1: exhibit the connection between voltage power provided to engine speed when we providing the ability to the engine.



Figure(f): Graph between voltage and speed of motor

Table Showing Cost Analysis and Distance:

Mode	Person Weight	Price	Distance Travelled	Price Per Unit Distance
Petrol	70	97(INR)	44.5	2.24
Battery	70	10(INR)	33.5	0.29
Power Saving Mode	65	0	12.6	0.00

Table 2: Cost Analysis and Distance

CONCLUSION

In view of this investigation of Electric Vehicle regenerative force framework for an Electric Bike, the accompanying ends can be drawn:

The conceived strategy was utilized to examine four substances, i.e., the engine proficiency, diminishing charging time of the battery, cost investigation and structure examination of an Electric bicycle. The structure and model of this electric bicycle could be conveyed monetarily a negligible measure of working expense and creation. In the current market, E-

bicycle has begun to pick up consideration of trailblazers and clients. With the movement in battery innovation, Electric bicycle convey a famous future in transportation. Right now, alternator has been fused with the goal that battery life has been expanded. With the change of configuration propelled controller, BLDC engine, other after enhancements executed in the structure, the speed of a vehicle is expanded variously.Yet it is possible to increase the speed of the bike with the help of more professionalism and robust chassis.

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