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DESIGN AND ANALYSIS OF REGENRATIVE ELECTRIC BICYCLE

Mahima P[1], Sagar R[2], Shubham T Honawade[3], Karthikraj Nayaka R N[4], Dr. Vijaya G[5]

[1234]UG Students, Department of Mechanical Engineering, DSATM, Bengaluru, Karnataka, India

[5]Asst. Professor, Department of Mechanical Engineering, DSATM, Bengaluru, Karnataka, India

Abstract: An innovative method for regenerating the power of an electric bike using a dynamo is known as a regenerative system for an e-bike. This is done with the goal of protecting the environment and replacing the need for fuel due to its depletion and excessive carbon emissions into the atmosphere, which cause severe pollution. Additionally, the battery's capacity for charging decreases proportionally as the bike is in motion. Waiting for batteries to fully charge is, however, a very time-consuming and cumbersome process if the charge distance exceeds 90km/charge. As a result, it is necessary to develop an environmentally friendly electric bike that can improve range and reduce environmental pollution with the help of regenerative or secondary power sources. Mechanical energy can be converted into electrical energy with this kind of system. A regenerative system for an electric bike has been proposed that consists of a Brushless DC motor, a blonde weight chassis, a controller, an alternator, a solar charging device i.e., MPPT kit and a lithium-ion battery will give a better performance and long life of battery with the assistance of battery management system. In this action, these parameters have been considered for the sequence: the motor efficiency, reducing battery charging time, cost analysis, and design analysis. The findings demonstrated that the speed and torque of the BLDC hub motor have a significant impact on the alternator's power propagation. The motor speed is 4000 rpm with 1kW of power and 48V 20amp specifications.

Key words: innovative, regenerating, battery, MPPT kit, lithium-ion battery, performance

I. Introduction:

Instead of driving a gasoline-powered vehicle, an electric bicycle provides a cleaner alternative for short- to moderate-distance transport. India has pushed towards a cleaner environment and reduced reliance on foreign oil in recent years. Over the past few years, the price of crude oil has climbed substantially, and it appears there is no stopping it. The environment has also received greater attention globally in recent years, and it appears that cleaner alternatives have been growing rapidly with no end in sight. The electric bicycle is a project that can support less reliance on oil and cleaner technologies.[1]

Here, we have used dynamo(alternator) to generate extra energy while driving and re-charge the battery which increases the km/hr. It also decreases the charging time compared to normal e-bike. A further advantage of creating the electric bicycle is that it may demonstrate to the general people how much less expensive it would be to convert their current bicycle into an electric one opposed than only using their gasoline-powered automobiles. Students in our situation have an opportunity because of the increased significance of the environment in the world. There are several ways that we can assist the economy as it attempts to recover from one of the worst depressions of the century. This is our chance to help make the globe greener and more effective.[2]

II. Methodology:

The idea behind making a setup based upon Regenerative System with an Alternator was clear, interesting and a challenging one as the area in which are investing our time and efforts was untouched till now, therefore we were very clear about the methodology that we were going to adapt in the making this setup. [3]

We had to do a lot of research about each and every component and build the required setup by ourself. We knew that directly getting into these topics were isn't easy and we needed a greater amount of guidance. After getting to know about the things to be done, we planned the following methodology to bring our idea into life.

1. To list the required specifications of each component.
2. To go in search of the components.
3. To alter or re-design to components to the required specifications.
4. Manufacture the designed parts and assemble.
5. Testing and analysis.

The flow chart of working methodology was noted and worked according to the same manner.[3]

III. Working Principle:

The term "Electromagnetic Induction" refers to the induction of an electromotive force by the motion of magnets across a conductive material caused by a change in the magnetic flux in a magnetic field. On the basis of the principle of Electromagnetic Induction, we insert and position the magnetic field and the conductor in it, either where the magnetic field is varying and the conductor is stationary or vice versa. The wheel is also moving when the EV is moving. As a result, the conductor's magnetic field changes, resulting in an electromotive force (EMF) and current. This current can be utilized in re-energizing a similar battery or then again, the reinforcement battery utilized for different purposes. The EV's travel range and battery cycle life will both be improved by this battery recharging. The chemical reaction that motivates the prime mover takes place here.[4]

A controller supplies power to the electric motor, and a rechargeable battery supplies power to the controller. The electric vehicle works on the principle of electricity and current. The electric motor is powered by batteries in a battery pack. The motor then rotates a transmission with the power (voltage) from the batteries, which turns the wheels. The battery transfers current when the bike is turned on. The controller takes power from the battery and sends it to the motor based on the throttle given.

The electrical motor uses mechanical energy to convert electrical energy. The vehicle is moved by the mechanical energy. The controller receives power from the battery and distributes it to the motor accordingly. Between the accelerator and the controller, there are connections for variable potentiometers.

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The CVT transmission system transmits the speed to alternator, which converts the mechanical energy into electric energy. The output of the alternator is connected to a solar charger which controls the voltage that needs to send to the battery for regenerative.

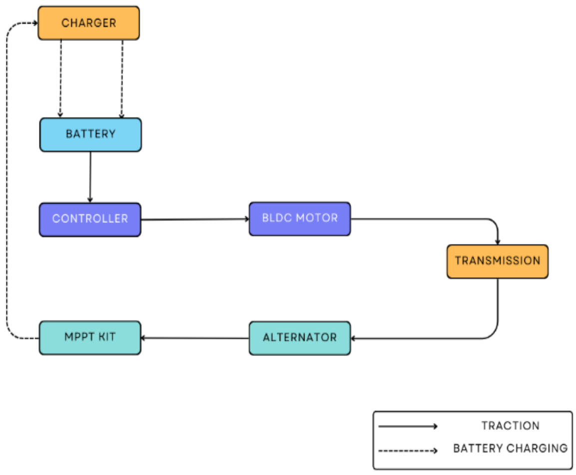

fig.1: Block Diagram of the working process

Solar device acts as a controller here to maintain the voltage that is supplied to battery in order to charge. The dynamo along with the solar kit acts as a regenerative unit. Fig.1 shows the block diagram of working process. [5]

IV. Components:

The following are the components used to setup the regenerative system:

4.1 Chassis:

An artificial object's chassis is its load-bearing framework, which structurally supports the object's construction and function. A Bicycle skeleton is the fundamental part of bicycle, onto which haggles parts are fitted. The most recent and prevalent chassis. A bike's chassis set typically consists of the frame and the front fork, as well as the headset and seat post. Manufacturers frequently produce the frame and fork as a paired set. A bike's core structure is called a chassis. It provides support for the rider, any passengers, or luggage, the steering and rear suspension, and the electric motor. The battery pack is attached to the frame as well. The steering head tube that holds the pivoting front fork is located at the front of the chassis, while the swing arm suspension's pivot point is located at the rear. The electric motor is a load-bearing stressed member on some motorcycles; whereas other bikes have a motor that is attached to both a front and a rear sub chassis instead of a single chassis.[6]

Here we have used Access 125 chassis in order to carry out our setup. The dimensions of the chassis is :

1.24m x 0.62m x 0.5m

Fig.2 and fig.3 show the top and side view of the framework of chassis respectively.

fig.2: Top view of the chassis

fig.3: Side view of the chassis

4.2 Alternator:

An alternator is a device used to convert mechanical energy into electrical energy. An alternator is a type of generator that produces alternating current (AC) power. It is used to charge a vehicle's battery and power the electrical systems while the motor is running. The main components of an alternator are the rotor, stator, and diode bridge. The rotor is a rotating magnet that generates a magnetic field, while the stator is a stationary set of coils that produce the electrical output. The diode bridge converts the AC output into DC power that can be used by the vehicle's electrical system. Alternators are very efficient at converting mechanical energy into electrical energy. They are designed to produce maximum power at low speeds, which is important for vehicles that spend a lot of time idling or driving at low speeds. Fig.4 shows 3HP alternator.

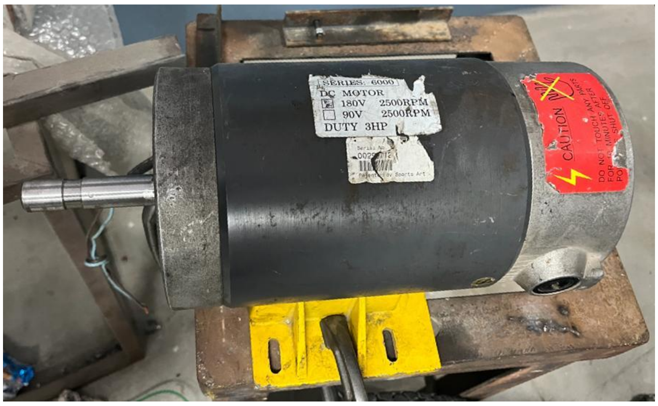

fig.4: Alternator

Here we have used an alternator with following specifications;

- Power: 2.23kW
- Speed: 4000rpm
- Voltage: 260V

The voltage output is connected to the solar kit in order the recharge the battery.

4.3 Brushless DC Motor:

By using high-energy permanent magnets as the field excitation mechanism, a permanent magnet motor drive can be potentially designed with high power density, high speed, and high operation efficiency. These prominent advantages are quite attractive to the application on electric and hybrid electric vehicles. Of the family of permanent magnetic motors, the brush-less DC (BLDC) motor drive is the most promising candidate for EV and HEV application. A BDLC motor drive consists mainly of the brush-less DC machine, a DSP based controller, and a power electronics-based power converter.[7]

The BLDC motor has the following specifications;

- Power: 1kW

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- Voltage: 48V
- Current: 20amp
- Speed: 4000rpm

The shaft in the BLDC motor was of the chain drive, as we are using belt drive with CVT transmission, we had to redesign the shaft according the requirement. The dimensions of the designed shaft is 400mm

The fig.5 and fig.6 show the shaft and BLDC motor respectively.

fig.5 : Redesigned Shaft

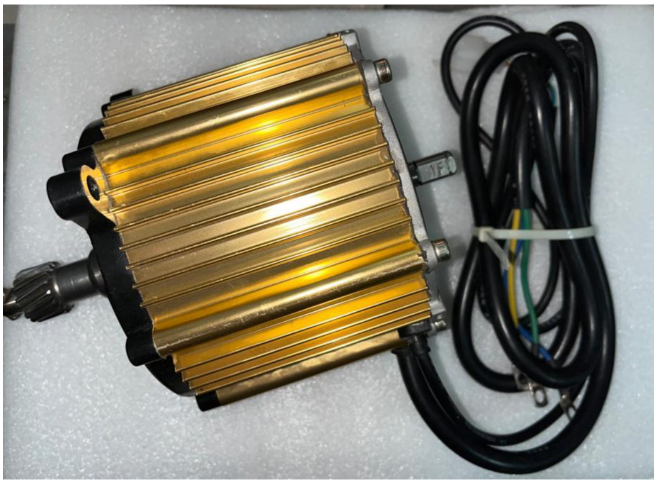

fig.6: BLDC Motor

4.4 Controller:

An electronic device that is used to control a brushless DC (BLDC) motor's speed and direction is called a BLDC motor controller. A BLDC motor controller's primary function is to generate three-phase AC power to drive the motor from DC power. It utilizes electronic compensation to control the planning of the ongoing stream in the engine windings to create revolution. A microcontroller or digital signal processor, power transistors, gate drivers, and current sensing circuits are the primary components of a BLDC motor controller. The motor's speed and direction are controlled by a DSP or microcontroller, and the current flowing through the motor's windings is switched by power transistors and gate drivers. In order to safeguard the motor from damage and prevent overloading, the current sensing circuits monitor the motor's current. Sensored controllers and sensor less controllers are two examples of BLDC motor controllers. Back electromotive force (EMF) detection is used by sensor less controllers to determine the rotor's position, whereas Hall-effect sensors are used by sensored controllers to provide precise information about the rotor's position. BLDC engine regulators can utilize a few different control techniques to manage engine speed and force. Direct torque control (DTC), field-oriented control (FOC), and pulse-width modulation (PWM) are examples of these.[8]

We have 48V 50amp Controller as shown in fig.7

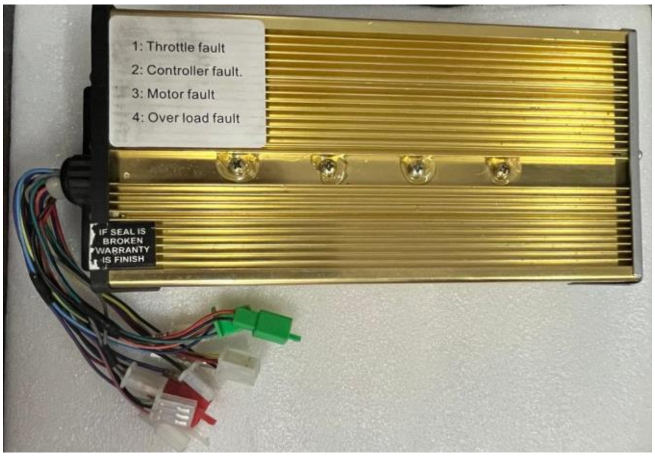

fig.7: Controller

4.5 MPPT Kit (Solar Charger Controller)

An MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.

This kit is used in our concept between the alternator and battery. The high voltage from the dynamo is reduced to required voltage of the battery. For example, if the vehicle runs at 2500rpm, so alternator produces 180V output and the Solar charge controller controls the amount of voltage that should reach battery to recharge, i.e., it converts 180V to 54.4V so that the battery can recharge.

The fig.8 below shows the 48V 40A MPPT device.

fig.8: MPPT kit (Solar Charge controller)

V. CVT Transmission:

While other types of mechanical transmissions offer a fixed number of gear ratios and have hard shifts between each, a CVT transmission, or continuously variable transmission, seamlessly changes through an endless range of effective gear ratios while you drive. According to Certified Transmission Repair, other types of mechanical transmissions offer a fixed number of gear ratios and have hard shifts between each, whereas a CVT, or continuously variable transmission, seamlessly changes through an endless range of effective gear ratios while you drive. CVT transmission frameworks are otherwise called single-speed, idle, and stepless transmissions.[9]

A CVT's shiftless design provides unmatched adaptability while preserving constant angular velocity at any output speed. Additionally, a continuously variable transmission provides improved fuel economy and smooth acceleration.

The below fig.9 shows the continuously variable transmission.

fig.9: CVT Transmission

VI. Charging:

According to our idea, battery can be charged in two ways; one using the charger and another by alternator.

A 48V 31.2Ah Lithium-ion battery is used and it is charged using a 54.6V 10amp charger. It takes about 3 hrs to completely charge the battery from 0-100%.

As the alternator and solar kit make a regenerative unit, it helps in recharging the battery while using it i.e., while the vehicle is in motion.[10]

VII. Testing and Analysis:

The testing was carried out in 3 phases:

1. Pre-testing with an arrangement of components on a table.
2. Testing without alternator.
3. Testing with alternator.

Stage I: Pre-testing:

The assembly was setup on a table, to check the range, power and speed of the motor, alternator and capacity of the battery.

This setup helps us to understand the transmission system and the ratio to be used.

The fig.10 below shows the setup on a table.

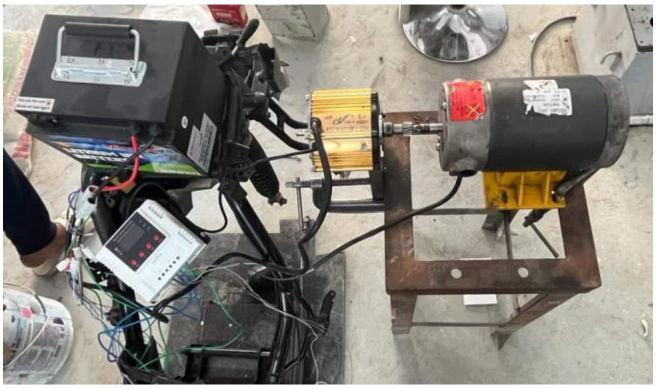

fig.10: Pre-testing setup

Stage II: Testing without the alternator:

In this testing process, the vehicle was tested without the use of alternator to check the performance.

The range of the e-bike was around a average of 60 km/charge with a battery life of 4hrs to completely drain out. The top speed reached was 50km/hr under a load of 200kgs.

It would take 10sec to reach 40km/hr. The battery was checked under kind of circumstances and the resulted are noted.

Stage III: Testing with alternator:

In this process, the regenerative unit i.e., alternator and solar charge controller was used to analyse the performance.

The range of the e-bike was around a average of 90 km/charge with a battery life of 6hrs to completely drain out. The top speed reached was 50km/hr under a load of 200kgs.

It would take 10sec to reach 40rpm. The battery was checked under kind of circumstances and the resulted are noted.

Considering both the testing performances we can see that the use of alternator has increased in battery life and range of vehicle.

The battery life of both can be compared and analysed that the range has increased by 50%.

VIII. Conclusion:

The battery will store the generated current so that it may later be utilised to power the electric vehicle. We have achieved the desired output by using alternator and solar charge controller unit as regenerative unit. The electric vehicle's journey distance has been extended. With no emissions at all, this will save a significant amount of energy. [11]

The battery will require significantly less time to charge because it is constantly self-recharging, which will be beneficial for long-distance commuters who won't have to look for or stop their EVs at charging stations and wait for the battery to fully charge for 2–12 hours.

As compared to gasoline vehicles, electric bicycles are much more sustainable and useful both economically and socially. But the major disadvantage was the long time to charge battery and availability very few recharging stations across India. By using our idea of regenerating the battery using an alienator will help to reduce this problem to a certain extent.

IX. Reference:

1. Chellaswamy Chellaiah “An Automatic Charging Mechanism and Electrical Energy Storage for Full Electric Vehicle” March 2016 International Journal of Applied Engineering Research
2. Francesco Paolo DEFLORIO, Luca CASTELLO, Ivano PINNA & Paolo GUGLIELMI “Charge while driving for electric vehicles: road traffic modelling and energy assessment” Journal of Modern Power Systems and Clean Energy volume
3. Priya Mishra, Karthiga Pandi, P. Srinivasan, M. Moovendan “Electric Bikes Over Fuel Bikes with the Help of ANFIS Model in India” International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8, Issue-1S4, June 2019
4. Ligil Vijayan, Shamil R.P, Subath Momin U, Yogeesh Rao “Free Energy Electric Bicycle” , IJERT ISSN:2278-0181 2019
5. Niraj K Naik “Regenerative Electric Bicycle” IJISRT 2019 Volume 4, Issue 3, ISSN: 2456-2165

6. Rohan Y Garud , Shahid C Tamboli ,Dr. Anand Pandey “Structural Analysis of Automotive Chassis, Design Modification and Optimization” IJAER ISSN 0973-4562 Volume 13,2018
7.
8. M. R. Hazari, E. Jahan, M. E. Siraj, M. T. I. Khan and A. M. Saleque, "Design of a Brushless DC (BLDC) motor controller," 2014 International Conference on Electrical Engineering and Information & Communication Technology, Dhaka, Bangladesh, 2014, pp. 1-6, doi: 10.1109/ICEEICT.2014.6919048.
9. Priyanka Grover Arora, Jane Alam Sagor “Design Approach of Regenerative System for an Electric Bike Using Alternator” 2018 JETIR Volume 5, Issue 12, ISSN 2349-5162
10. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles-Fundamentals, Theory, and Design” CRC Press
11. Nitipong Somchaiwong and Wirot Ponglangka “Regenerative Power Control for Electric Bicycle” SICE-ICASE International Joint Conference 2006