

Design of Electric Vehicle with the Help of Regenerative Braking System



Ashwath, Bala Chandru, Harish Kumar, Karthikeya S. Narendiran, and P. Manju

Abstract This paper systematically discusses the design and control methodology of an electric bike. The design methodology focuses on the efficient usage of a battery using the regenerative braking system. The battery used to operate is a lead-acid battery. Control strategies focus on regenerative braking and efficient charging/discharging of batteries. A real-time model of the electric bike has been fabricated after successfully designed in computer-aided design and drafting (CADD). During the initial phase of testing the real-time, electric bike, the voltage generated while applying the brake is sufficient to initially charge the battery.

Keywords HUB motor · Regenerative brakes · Battery · Controller · Control methodology

1 Introduction

Fuel bike produce a lot of carbon monoxide which goes to atmosphere causing pollution and producing green house gases [1]. E-bike as an alternative transportation would be ideal for fast travel using e-bike has the burden of having short driving range.

Conventional braking system

During braking, kinetic energy gets converted into heat energy which dissipated to the surroundings part of energy escalated from engine get wasted and further energy is required to accelerate the vehicle [2].

Regenerative braking system

Regenerative braking system is an energy recovery system that recover significant amount of kinetic energy of the vehicle that unnecessarily gets wasted during braking

Ashwath (✉) · B. Chandru · H. Kumar · K. S. Narendiran · P. Manju
Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India
e-mail: 16TUIL007@skct.edu.in

K. S. Narendiran
e-mail: narengaag@gmail.com

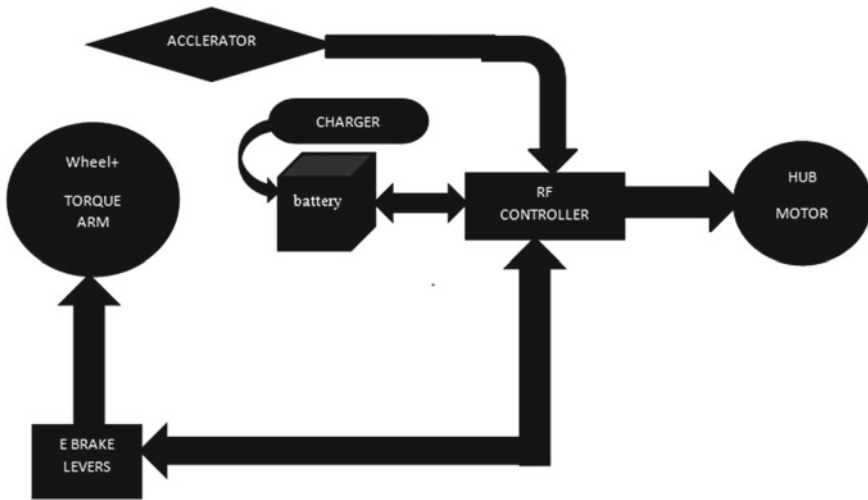


Fig. 1 Control flow diagram of the proposed system

regulations on exhaust emission from vehicle engines have been made progressively more and more stipend toward the year 2000 and beyond, 0 vehicle manufactures have been hence obliged to meet these standards by design cleaner and fuel efficiently engines and through provision for treatment of exhaust gases to satisfy the specified limits [3]. So to satisfy and overcome these two problems namely pollution and efficiency.

Hence, a need for a change in the existing alternative system which can produce higher efficiency at minimum cost was though about an attempt has been made to design and fabricate such an alternative system. So, this project “Regenerative brake and reverse motor” is very much useful, since it is provided with good quality of power sources and simple operating mechanism. Hence, “EACH AND EVERY DROP OF FUEL SAVES OURECONOMY AND MEET THE NEEDS” is the saturation point that is to be attained as soon as possible [4] (Figs. 1, 2).

2 Proposed System

The significant parts that are viably utilized in the fabrication of the regenerative braking system, and powered bike are described below:

- Battery
- Bearing with bearing cap
- Controller
- Electronic brake levers
- Torque arm
- Motor

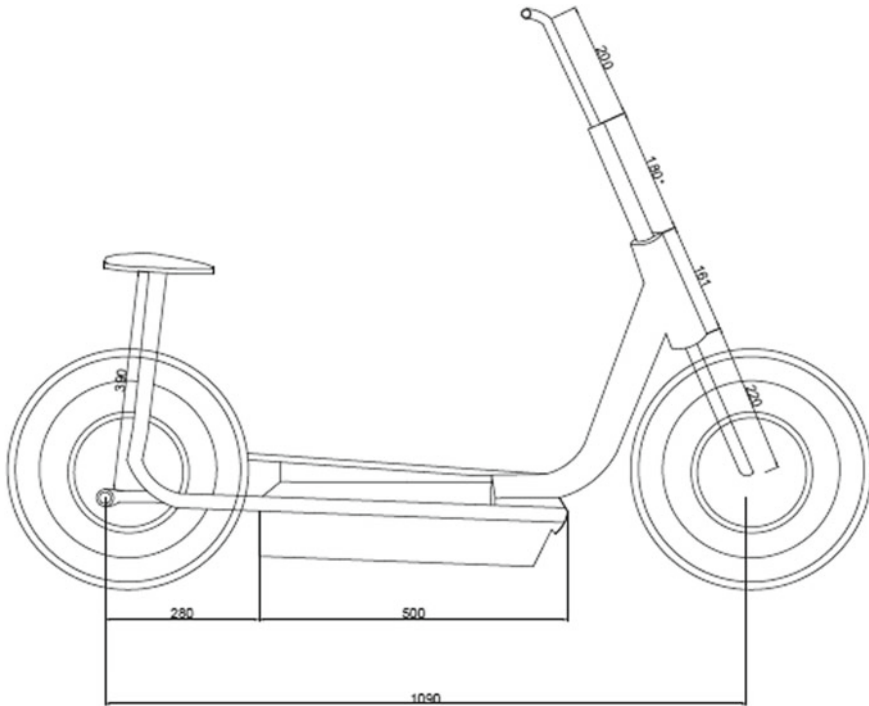


Fig. 2 2 Dimensional view of the proposed e-bike

Batteries are utilized for storage of overabundance sun powered vitality changed over into electrical energy. The main special cases are confined daylight burden, for example, water system siphons or drinking water supplies for storage. Indeed for little units with yield less than one kilowatt. Batteries appear to be the main actually and economically accessible stockpiling implies since both the photovoltaic system and batteries are high in capital expenses.

It is fundamental that the general framework be streamlined regarding accessible vitality and nearby request design. To be frugally smart, the storage of charge by regenerative braking needs a battery with a specific mixture of things like long life, low cost, high overall efficiency and reliability, low discharge, and minimum maintenance.

2.1 Battery Setup

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example,

Fig. 3 Real time battery setup



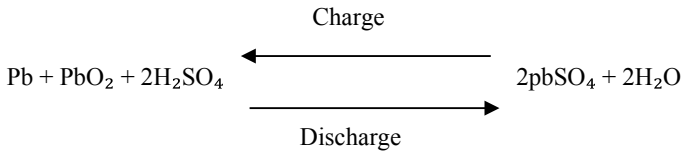
the load current to the starter motor is typically 200–400A. One cell has a nominal output of 2.1 V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery. The lead-acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge of scooty can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortens the useful life to about 3–5 years for an automobile battery. Of the different types of secondary cells, the lead-acid type has the highest output voltage, which allows fewer cells for a specified battery voltage (Fig. 3).

2.2 Assembly of Battery

Inside a lead-acid battery, the positive and negative electrodes consist of a group of plates welded to a connecting strap. The plates are immersed in the electrolyte, consisting of 8 parts of water to 3 parts of concentrated sulfuric acid. Each plate is a grid or framework, made of a lead-antimony alloy. This construction enables the active material, which is lead oxide, to be pasted into the grid. In assembling of the cell, a charge forming creates the terminals of negative and positive.

In the procedure of forming, the dynamic material is changed to lead peroxide (PbO_2) due to positive plate. The negative electrode is spongy lead (Pb). Batteries for automobile are typically transported dry from the maker. The electrolyte is placed in at the hour of installation, and afterward, the battery is charged to from the plates. With maintenance less batteries, zero water needed during ordinary service. A few

kinds of batteries are fixed, aside from a pressure vent, without arrangement for including water.



3 Bearing with Bearing Cap

The bearings are squeezed to fit into the shaft in such a case that pounded the bearing may create splits. Bearing is comprised of steel material and bearing top is mellow steel.

3.1 Introduction

In order to minimize the power loss and friction ball, roller bearings are used. In olden days, the design and manufacturing of ball bearings are difficult. After a lot of research work carried out in this, a perfect design has been done though this technology in its present state. The benefits of this work can be used only if we use a proper size and type.

Adequate mounting, sealing, and lubrication should be done on the bearing. The sources available for the design engineers to obtain the information about selecting the bearing for a particular application are based on the manufacturers and textbooks. The bearing cap is used as shaft that rotates the wheel to move on where without the bearing the wheel cannot rotate with the constant speed (Fig. 4).

4 Torque Arm

A torque arm is an additional bit of help metal added to a bike casing to more safely hold the pivot of a hub motor. In any case, how about we back up and get some perspective point of view on torque arms when all is said in done to realize when they are necessary and why they are so significant.



Fig. 4 Bearings in e-bike wheel

4.1 Working

Torque arm helps in collecting the energy that are exhaust as a waste in the form of the friction will applying the brake the torque arm touches the wheel as like dynamo, and the friction between the wheel and the arm collects the significant amount of energy which is sent to the battery in the form of voltage.

5 Hub Motor Controller

The electric vehicle controller is the core control device used to control the start, run, advance and retreat, speed, stop, and other electronic devices of the electric vehicle. It is like the electric car's brain, which is an important part of the electric car. Electric cars including electric bicycles, electric two-wheeled motorcycles, electric tricycles, electric three-wheeled motorcycles, electric four-wheelers, battery cars, and electric car controller (Fig. 5).

5.1 Working

Over/under voltage protection function offers real-time battery current monitoring (optional). Single periodic current adjustment provide over voltage protecting in micro second rates with thermal sensor to detecting any thermal information.

Safety reversing function, reversing speed can be set by 30% to 50% of the forwarding speed providing +5 V powering to hall sensor with over current protecting, configurable forwarding, and neutral. 5 wires access of hall sensor connector. Real-time battery current monitoring system makes sure the output current

Fig. 5 Hub motor controller

will not exceed the maximum battery working current. In this method, the work of the controller is to toggle the pulse form variation that the energy required to drive the motor and the energy taken from the battery are grouped together the variation of the pulse is corrected by this controller and then send it to the driven DC motor.

6 BLDC Motor

Torque is developed when a motor is in operation. Mechanical energy is produced due to this torque. To power the associated components of bike like regenerative braking, fault protection, and motoring control, and microcontroller unit a brushless DC motor is used (Fig. 6).

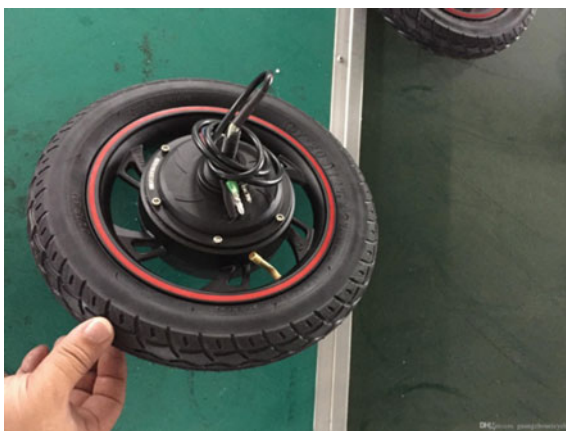
Fig. 6 Motor attached with wheel

Table 1 Speed of bike and voltage generated during testing

	Test 1	Test 2	Test 3	Test 4
Rotation of bike wheel per minute (RPM)	84.9	247	494	1294
Voltage generated during braking (V)	0.29	4.87	8.53	11.27

6.1 Working Principle of Regenerative Brake

A regenerative braking system is installed in the suspension of the bike which converts the kinetic energy experienced by the brake into useful electrical energy. Controller is fixed to the front side of the bike so that whenever throttle of vehicle position varies, the energy stored in a battery gives.

This power is used to charging the battery, so the battery will quickly charge. This is in turn stored up in a battery and also indication setup is provided in the front of the vehicle which gives necessary details when the bike moves. This rotation is converted into electrical energy and stored in the battery. A switch is provided in the bike to toggle between regenerative braking and hydraulic braking. When this is pressed, the energy from the battery is delivered to the motor which drives the rear wheels of the bike through the chain and sprocket drive.

This in turn drives the front wheels resulting in the motion of the bike. In addition to the regenerative braking, it can able to gain overall energy of up to 10–15.

6.2 Results and Discussion

The initial voltage in the bike is generated when the RPM of the wheel is around 84.9 during Test 1. The second phase of voltage in the bike is generated when the RPM of the wheel is around 247 during Test 2. The third phase of voltage in the bike is generated when the RPM of the wheel is around 494 during Test 3. The next phase voltage in the bike is generated when the RPM of the wheel is around 1294 during Test 4. Thus, it clearly indicated that when the speed of the bike is increasing and if the brake is applied, the voltage is generated as shown in Table 1 and pictorial representation id depicted in Fig. 7.

7 Conclusion

This bike can reduce a significant amount of electrical energy dependency and the fuel supply scenario in the future in the field of transportation. Design methodology developed in this paper has been successfully implemented during the testing phase 1. The regenerative braking system in the electric bike will provide the outcome of

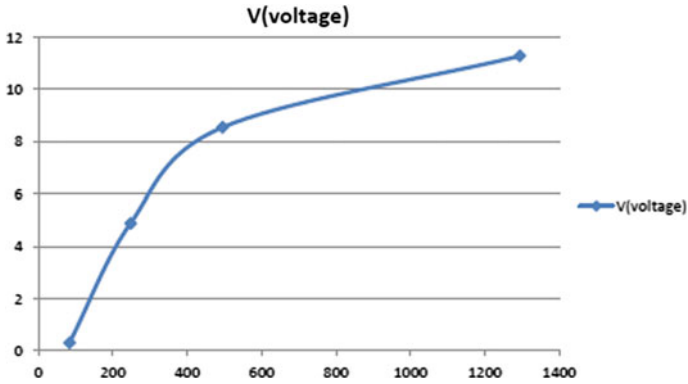


Fig. 7 Voltage versus RPM of the bike during phase 1 testing

5–10% of gain in charge. In this e-bike, regenerative braking and efficient battery management system are the key technologies.

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