Grenze International Journal of Engineering and Technology, Jan Issue

Customized E- Bike

Prof. Vaibhav Baburao Magdum[1] and Prof. Ravindra Mukund Malkar[2]
[1-2]Assistant Professor, Electrical Engineering Department, DKTE Society's Textile and Engineering Institute, Ichalkaranji, (MS), India.
Email: vaibhavmagdum@dkte.ac.in, rmmalkar@dkte.ac.in

***Abstract*—Traveling has been necessary for various activities all around the world since it makes the businesses grow. The mode of transportation, particularly the vehicles being used for transportation, is now being scrutinized due to environmental concerns. Internal combustion engines cause pollution as they utilize natural resources of oil and gas and emit greenhouse gases like carbon monoxide, which contribute to global warming. Despite the promotion of alternative fuels such as biodiesel (ethanol), there is still a strong focus on creating transportation systems based on electrical energy. The conversion of electrical energy into mechanical energy is pollution free. Hence people in metro cities are abandoning IC engine vehicles in favor of electric vehicles. This paper describes the components and factors to be considered for converting a petrol-powered (IC Engine) scooter bike to an electric bike.**

***Index Terms*— E-bike, electric bicycle, regenerative braking, speed control.**

I. Introduction & Literature Review

An electric bicycle has a standard bicycle frame, pedals, cranks, chain, and freewheel assembly. Human power can be supplemented or replaced with electric propulsion. Some key points regarding accessories interfacing like brakes, lights, indicators, switches etc. are mentioned in [1]. Brushless DC Motors are recommended over permanent magnet DC Motors [2] for driving electric bikes. The efficacy of BLDC Motors, which are efficient and controllable, is driving this evolution. PWM control is used to control the speed of BLDC motors. Several design related guidelines are provided in [3] for improvements in the performance of electric bicycles.
The performance evaluation of electric bicycles is discussed in [4]. Custom-designed drives that are most efficient throughout a certain operating cycle could solve the challenges with electric bicycles. City bicycles, hill bicycles, distance bicycles, and rapid bicycles are among them. In general, there are two kinds of electric bikes. One is pure electric bikes in which pedaling force and motor power could be driven independently. Even in the absence of rider pedaling force, the motor could provide the power. The other is electric-assist bikes, which are human–electric hybrid bicycles, supporting the rider with electric power only when the rider is pedaling [5]. The Fuzzy Logic controller can be used to address problems relating to the use of electric motors in electric bikes. The two main issues being loading conditions that cause the system to deviate from its set point and the bike's speed response to attain steady state [6].
A Study for developing the Energy Recovering Circuit for Modern E-bike Controller is presented in [7]. Through regenerative braking, the energy lost during electric vehicle deceleration can be collected and utilized in other operations. Recovering kinetic energy and storing it in the battery bank is one of the most difficult aspects of Energy Management in electric vehicles. The amount of power recovered is related to the vehicle's speed. The design and development of an electric bike involves many electrical and mechanical aspects. By removing the

Grenze ID: 01.GIJET.9.1.512

engine and exhaust system and replacing them with a motor and battery with the appropriate controller, a cost-effective electric bike model can be created. Frame development, material selection, and assembly are all part of the mechanical system design. The electrical system, on the other hand, consists of a motor, battery bank, speed controller, and related accessories. The hardware design guidelines for designing an electric bike and also the design criteria for an effective selection of the main components of the electric bike such as the motor selection, battery selection, controller selection, material selection, brakes and suspension system are listed in [8].
Here electric propulsion system using BLDC motor with sensor based speed control can be adopted to overcome imitations & expenses of sensors [9]. The quantification of regenerative braking energy in a two-wheeler incorporating various duty cycles is discussed in [12].

A. E-Bike Components

Electric Motor (PMDC / BLDC), battery, motor speed controller, frame and wheels are basic building elements of electric Bike [13]. The following section describes components required for building electric Bike

Electric Motor

The motor transforms electrical energy rotational mechanical energy. It generates torque and subsequently propels the vehicle. BLDC motor is widely used in industrial applications on account of its large torque output, low noise, high efficiency and better stability. The speed control of BLDC motor is achieved by PWM control or field oriented control (FOC) method [14]. A BLDC hub motor will replace petrol based IC engine in conventional Bike.

Figure 1: Photograph of BLDC hub motor

Motor Controller

The electric Bike controller is one of the main parts of an electric Bike. It is the brain of the electric Bike, controlling the motor's speed, start and stop. It is connected to all the other electronic parts such as the battery, charger, motor, throttle and display panel. The prime function of electric Bike controller is controlling the speed of the electric motor and thereby setting the Bike into motion. The choice of controller depends on type of motor and battery voltage rating. Different types of controllers are used for brushed and brushless motors.

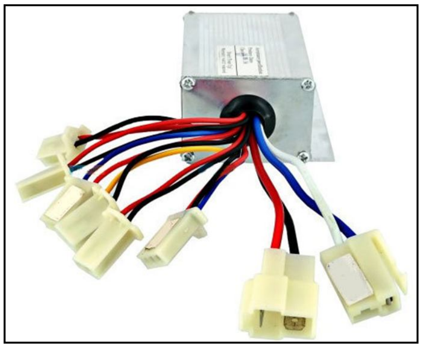

Figure 2: E-bike controller

Battery

A battery converts chemical energy into electrical energy and vice versa. A battery is composed of cells. These cells are assembled in series and parallel combination so as to bring it to the required specifications. The technical specifications of battery are mentioned in terms of nominal voltage, capacity in Ah, nominal energy, life cycle, maximum discharge current, charging voltage, charging current and internal resistance. For powering of electric Bike lithium ion batteries are considered as the best choice battery due to their high energy density, small losses, higher life span and ability to recharge for countless times [15]. The life expectancy of typical electric Bike battery is between 3 – 4 years.

Figure 3: Lithium ion battery

Frame and Wheels

The chassis is the frame that supports the vehicle’s body as well as the power train. The engine and drive train, axle assemblies comprising the wheels, suspension sections, brakes, steering components, and other mechanical components are fastened to the chassis. The chassis provides the necessary strength to accommodate the various vehicle components as well as the cargo, as well as keeping the vehicle rigid and stiff. It also guarantees that noise, vibrations, and harshness are kept to a minimum throughout the vehicle [18]. It is expected that the frame of the vehicle should be light and strong enough to support all the mountings. The wheel diameter of bike under consideration is 16 inches (40 cm) and has load capacity of 100kg and chassis weight is 40kg.

Figure 4: Bike under consideration

II. E-BIKE CALCULATION

The main electrical component of e bike is drive motor. The motor power rating depends on total force (in turn torque) required to set the Bike into motion. For calculating total force required to be generated by motor, the physical parameters mentioned in table 1 are considered.

TABLE I. PARAMETERS CONSIDERED FOR ELECTRIC BIKE CALCULATIONS

Sl. No.	Parameter	Value
1	Raider Weight	100 kg
2	Speed of vehicle	40KM/ Hr = 11.11m/s
3	Coefficient of rolling resistance (μ)	0.015
4	Gravitational acceleration	9.81 M/S^2
5	Air density (ρ)	1.25 kg/M^3
6	Weight of Bike chassis	40kg
7	Front area	0.5 M^2
8	Drag coefficient (C_d)	0.3 – 0.7 (Avg. 0.5)
9	Slope angle (θ)	30°
10	Wheel radius	0.2 M
11	Vehicle Acceleration	0.55 M/S^2

The total traction force (in Newton) of electric Bike is,

$$F_T = F_R + F_{ad} + F_{slope} + Ma + {}^{a}/_{r^2}$$

Where,
F_T = traction force, F_R = Rolling resistance, F_{ad} = Air drag, F_{slope} = Hill climbing force,
M = Mass, a = Acceleration, r = Radius of the wheel
The rolling resistance is calculated as

$$F_R = \mu Mg\cos\theta = 1.81 \text{ N}$$

The air drag force is,

$$F_{ad} = \frac{\rho C_d A V^2}{2} = 19.34 \text{ N}$$

The climbing force is,

$$F_{slope} = Mg\sin\theta = 70 \text{ N}$$

Considering acceleration of vehicle as 0.55 m /s^2, Acceleration force is,

$$F_a = M\,a = 7.84 \text{ N}$$

Taking radius of the wheel to be 0.2M,

$${}^{a}/_{r^2} = 13.75$$

Therefore the total traction force is,

$$F_T = 112.74 \text{ N}$$

The torque required for motor is,

$$\text{torque } (\tau) = \text{Force } (F_T).\,r.\sin\theta = 11.27 \text{ Nm}$$

The required speed of the hub motor is calculated by considering the wheel specification as follows:
The diameter (d) of wheel is 40cm = 0.4M
The circumference of wheel = π.d = 1.256M
Hence in one rotation of wheel, the vehicle travels distance of 1.256M. Thus, for traveling distance of 40KM (40,000M), number of rotations of wheel required is = 31,847. These many rotations are required in one hour to attain speed of 40KM/Hr. thus the required RPM of motor is,

$$\text{RPM} = \frac{31847}{60} = 531 \text{ RPM}$$

The power rating of the motor is calculated from torque as

$$P = \frac{\tau.\,n}{9.5488} = 626.\,\text{W}$$

Hence, for the construction of electric Bike a brushless DC motor with following specifications is selected to replace the fuel engine.

Power = 1 HP
Voltage = 48V
Speed = 550 RPM
The developed vehicle is expected to reach 40KM/Hr speed and travel 100KM range in single charge of battery. Thus at the rated speed, the battery will be drained at capacity of 13.6 A per hour. Hence battery is selected with voltage rating of 48V and 35Ah current capacity.

III. CONCLUSION

For eco friendly transport, electric Bikes become first choice over fuel power Bikes. Not just air pollution but also noise pollution is significantly reduced with electric vehicles. The permanent magnet brushless DC motor offers higher efficiency, longer life better torque speed characteristics and almost noise free operation. By converting the conventional IC Engine Bike to Electric Bike the operation cost i.e. travelling cost can be reduced from Rs. 2.5 per km to Rs. 0.30 per km, considering the cost of petrol at Rs. 100 per liter and cost of electricity at Rs. 10 per unit. Thus with the conversion of Conventional Bike into Electric Bike a cost effective traveling can be achieved.

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