

Restructuring and Development of Conventional Bike for Electric Vehicle Application

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Abstract: In this paper, the Skelton of conventional bike is chosen for converting it into battery operated Electric vehicle. The work is done in two aspects: one is restructuring and other is assembling of powertrain components. Structural modifications are made for the placement of BLDC Motor with controller and Battery. The energy source selected is Lithium-ion battery and BLDC motor is used for propulsion of wheels of the bike. The Comparative analysis of gasoline conventional bike and developed E-bike is presented in this paper.

Keywords: Electrical Vehicles, E-Bike, BLDC Motor, Lithium-ion Battery, Powertrain.

I. INTRODUCTION

The major concern in today's generation for existence of living is pollution. As every individual life is engaged with work, requires transportation in deed use Gasoline vehicles which is one of the major issues for environmental hazard. The air quality in most Indian cities that monitor outdoor air pollution fail to meet WHO guidelines for safe levels. India is in the group of countries that has the highest particulate matter (PM) levels. Its cities have the highest levels of PM10 and PM2.5. The government has formulated a Scheme for Faster Adoption and Manufacturing of Electric and Hybrid Vehicles in India, under the National Electric Mobility Mission 2020 [1].

The main components of the pure Electric vehicle are Energy storage system, Motor with controller. The Lithium-ion Battery has more advantages when compared to the other batteries like high specific energy, high specific power and high life cycle (charge/discharge), but the cost is high. So it is suited for applications needed with high end performance [2]. Safety is a concern for Li-ion Battery which has thermal issues, sensitive to overcharge and deep discharge, which may damage the battery, shortening its lifetime, and even causing hazardous situations. So Battery Management System (BMS) technology is developed to provide all safety features [3].

II. WIRING CONNECTION AND OPERATION OF AN E-BIKE

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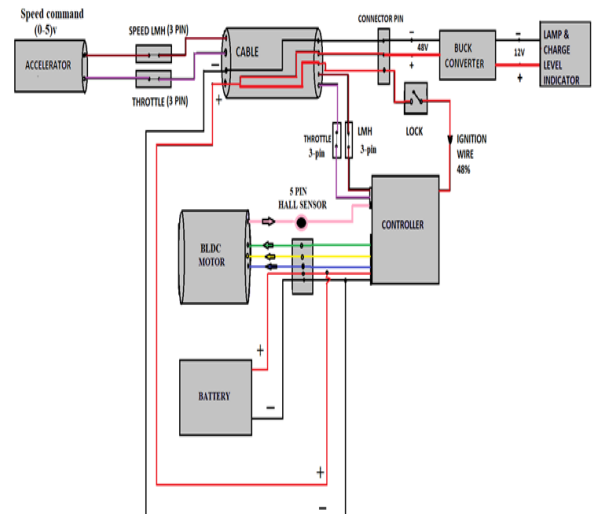


Fig.1: Electrical wiring circuitry of an E-Bike

II.I. Description:

The reference voltage is given as speed command. The reference voltage is in the range of (0-5) V. The accelerator is connected to the controller through throttle and speed pins. The speed switch has three ranges of speed operation which are Low, Medium High and termed as LMH switch.

II.II. Operation of E-Bike:

The lock is provided such that when it is operated then the bike is ready to start. The speed can rise/fallen through accelerator as a command signal given to the controller in the chosen speed limit using LMH switch. The driver circuit in the controller generates switching pulses given to the 3-φ Inverter. The output of Inverter is given as input to the BLDC motor and through powertrain the wheels gets accelerated/decelerated. The buck converter is used to step down the voltage from 48v to 12v DC for lamp and charge level indicator.

III. SIZING OF ELECTRIC MOTOR

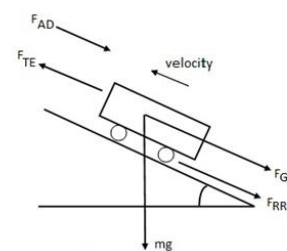


Fig.2: Various forces acting on a vehicle moving along a slope

In this section the mathematical formulation for the calculation of electric motor power and torque is presented. The total Tractive effort is the sum of all forces acting on a vehicle moving with a velocity 'v', having mass 'm' along a slope of angle θ shown in the fig.2[4].

$$F_{TE} = F_{RR} + F_{AD} + F_G + F_{LA} \quad (1)$$

Where

F_{TE} : is the Total Tractive Effort delivered by a powertrain.

F_{RR} : is the Rolling Resistance Force

F_{AD} : is the Aerodynamic Drag Force.

F_G : Gradient force.

F_{LA} : is the Linear Acceleration Force.

The following are mathematical expressions for calculating forces acting on a moving vehicle shown in the fig.2.

$$F_{RR} = \mu_r mg \quad (2)$$

Where

μ_r is the coefficient of rolling resistance.

$$F_{AD} = \frac{1}{2} \rho A C_d v^2 \quad (3)$$

Where

ρ is the density of Air (kg/m^3)

A is the Frontal Area (m^2)

C_d is the Aero dynamic drag coefficient

v is the velocity (m/s)

$$F_G = mg \sin\theta \quad (4)$$

$$F_{LA} = ma \quad (5)$$

The Power (P) required to overcome all these forces is given by

$$P = (v) * (F_{TE}) \quad (6)$$

The sizing of electrical motor is done by considering Eq.(6) and also losses of motor. Therefore Motor rating is given by Eq.(7).

$$\text{Motor rating} = \frac{P}{\eta_{\text{motor}}} * 100 \quad (7)$$

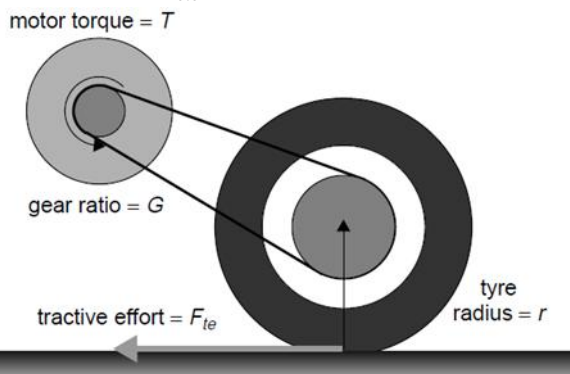


Fig. 3: Arrangement for connecting a motor to a drive wheel

The Axle and Motor Torque are calculated from equation (8) and (9).

$$\text{Axle Torque } (T_a) = F_{TE} * r \quad (8)$$

Where 'r' is the radius of the wheel.

$$\text{Motor Torque } (T_m) = \frac{T_a}{G} \quad (9)$$

Where 'G' is the Gear Ratio of the system connecting the motor to the Axle.

IV. MATHEMATICAL ANALYSIS FOR MOTOR SIZING AND BATTERY PERFORMANCE

Parameters:

Total bike weight and one person weight (m) = 70 + 70 = 140Kg.	
Speed of the vehicle (v) = 20 kmph = 5.55 m/s.	
Coefficient of rolling resistance (μ_r) = 0.011 for concrete road	
Inclination angle 'θ' from reference ground = 18 deg.	
Aero dynamic drag coefficient (Cd) = 0.7	
Density of Air (ρ) in kg/m^3 = 1.25	
A is the Frontal Area (m^2) = 0.9	
Radius of the wheel (r) in m = 0.3	
Gear ratio = 3	

The following tabulations are the computational values of opposing forces and power required for the movement of vehicles by using equations (1) to (6).

F_{RR} (N)	F_{AD} (N)	F_G (N)	F_{LA} (N)	F_{TE} (N)
15.107	12.12	7.52	77.7	112.447

Table.1: Computed values of Forces

P_{RR} (W)	P_{AD} (W)	P_G (W)	P_{LA} (W)	P (W)
83.84	67.31	41.77	431.23	624

Table.2: Computed values of power requirement

The Efficiency of a BLDC Motor is around 80%. By using eq. (7) the Motor rating is 780 W. Hence In the development of E-Bike the power rating of Motor is chosen as 750W.

From Eq. (8) and (9) Axle Torque is 33.73 N.m and Motor Torque is 11.24 N.m

The Rated Current of the BLDC motor = 13.5 A.

Battery Specifications		Battery Energy (Kwh)	Charging Time (hr) at the rate of 10A charger	Discharge Time at Full Load
Voltage	A.h			
48	35	1.68	3 hours 30min	2 hours 35 min

Table.3: Battery specifications and performance

V.COMPARATIVE ANALYSIS OF GASOLINE MOTOR BIKE AND E-BIKE& RESULTS

Cost of the project = Rs. 52,000.

(Includes cost for Battery, Motor with Controller, Adapter, Bike Skelton, Miscellaneous).

Range of E-Bike per unit Charge = (Discharge Time) * (Speed).

Cost for 1 unit or 1 kwh of energy consumption is taken as Rs. 1.45.

Savings in life period for E-Bike = (Cost incurred for Gasoline Bike for 31,200 kms) - (Cost for energy consumption by battery).

Parameter	Gasoline Bike	E-Bike
Initial Cost	Rs. 60,000 (Bajaj Platina 110)	Rs. 52000
Top Speed	Around 80 kmph	20 kmph
Range in km.	50 km/litre	52 km/charge
Cost of Refill /Recharge	Rs. 80 / litre	Rs 2.43/Charge @ Rs. 1.45/Unit
Pollution	Applicable	Nil
Life cycle/period	5-10 years conditions apply	Around 600 recharge cycles
Total Distance in Life cycle	Around 80,000 km	31,200 km
Savings in life period	NA	Rs. 45,000

Table.4: Comparative Analysis of Gasoline Motor Bike and E-Bike

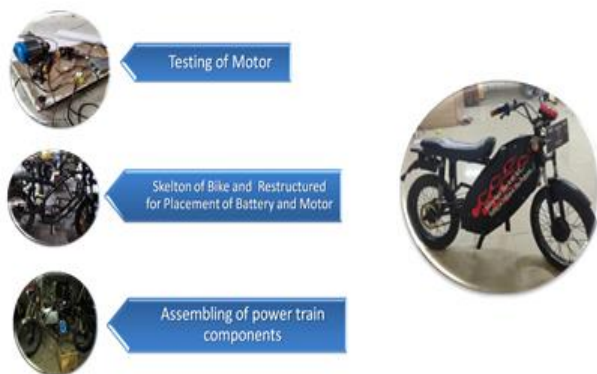


Fig.3: Glimpses of working stages for the development of E-Bike

VI.CONCLUSION

The Developed E-Bike is purely Battery operated Electrical Vehicle. The work is done by converting the Gasoline conventional Vehicle through restructuring and assembling of powertrain components. The mathematical analysis is made for the selection of motor and Battery. The savings of E-Bike is computed by considering life cycle of the battery.

The Developed E-Bike is suited for low speed operation on public streets where the speed limit is not more than 30 kmph. It is also recommended for the old age people to ride safely at lower speeds. The trend of developing E-Vehicles is encouraged as it is pollution free.

The work can be extended by integrating solar panels with MPPT controller connected to the battery as a energy source for continuous run of vehicle.

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