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Design And Development Of Electric Scooter

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Abstract: *India has the second-highest population in the world, next to China. India also seconds the list of largest manufacturers and producers of 2 wheelers. With the rise in the price of petrol and diesel, vehicles are not cost-effective based on fuel consumption. Replacing the conventional I.C engine with the electric engine can give enormous advantages like low cost, less maintenance, pollution-free, noiseless, smooth drive experience, and many more features. Electric Scooter is a replacement for traditional scooter bikes with the above merits. Indian 2 wheeler industry has got spectacular growth in last few years. It is expected that the Indian Electric 2-wheeler and associated division can produce large revenue by 2030. This paper represents the design and development of an Electric Scooter in a simple manner. Chassis is an essential part of the scooter as it is the Structural foundation of the vehicle. The material used here is Structural Steel because of its higher strength and lightweight. This project is aimed to develop and design a lightweight battery-operated E-Scooter using a BLDC hub motor transmission system. Which is having a load-carrying capacity of 100 kg with 60 kmph speed.*

Keywords: Electric-Scooter, Lithium-Ion battery, BLDC motor, Power, Controller

1. INTRODUCTION

As the name suggests Electric scooter is that in need of a scooter or vehicle that runs with help of electricity. Unlike traditional scooter runs supported petrol or gas, it doesn't require fuel for running. These are often recharged with help of A battery charger. Electric scooters are an environmental-friendly transportation medium that's going to be used by our future generation broadly. E-Scooters are green and economical which is a crucial factor for social and economical development nowadays.

An electric scooter consists of three major parts that are:

a) Battery
b) Controller
c) Motor

- The battery is used to store energy in sort of electricity, which can be employed by the hub motor.
- The controller gathers electricity from the battery and delivers the acceptable amount of electricity to the electrical motor
- The motor receives the facility from the battery and converts the electricity into mechanical energy.
- The wheel which is connected to the motor turns and thus the vehicle moves.The wheel which is connected to the motor turns and therefore the vehicle moves.

2. OBJECTIVE

- To get familiar with the components E-Scooter
- To Calculate the motor, battery, and charger requirements
- To reduce the running cost of the scooter

3. DESIGN

3.1 Chassis

Chassis is the structural foundation of a vehicle upon which all other components are getting to be fabricated.

Everything related to the vehicle except its body is contained by the chassis and is consists of a frame, transmission system, wheels, and control system.

The main function of the Chassis is to provide safety, carry the utmost load, and hold all the components during running.

3.2 Material Selection

Here Structural Steel is used for manufacturing the chassis. The main reason behind using structural steel here is because of its ability to absorb the impact produced in a collision, it is low cost compare to other materials. It has a better strength-to-weight ratio i.e it has high strength and less weight which results in improvements in the performance of the scooter

TABLE 1 *Properties of Structural Steel*

Material Property	Value
Density ρ	≈ 7850 kg/m^3
Unit weight γ	≈ 78.5 kN/m^3
Modulus of elasticity E (Young's modulus)	210000 MPa
Shear modulus G	$G = E / [2 \cdot (1 + \nu)]$ ≈ 81000 MPa
Yield strength f_y	see table below
Ultimate strength f_u	see table below
Poisson's ratio in elastic range ν	0.30
Coefficient of linear thermal expansion α	12 ×10^{-6} °K^{-1}

3.3 Design Specification

Mass of the vehicle = 100 kg

Weight of the vehicle = (100 *9.81) N = 981 N

Speed Of Vehicle = 60 km/h = 60*(1000/3600) = 16.67 m/s

(For Calculating Resistance due to motion)

1. Force due to climbing hills (F gradient)

F_h = W sin Φ (Angle of incline Φ is 2.5)
= Mg sin Φ
= 981x sin 2.5
= 42.79 N

2. Rolling resistance :

$Fr = Cr\ W \cos\Phi$ (for asphalt roads Cr=0.004)
$= 0.004 \times 981 \times \cos 2.5$
$= 3.92$ N

3. Air resistance:

$F_d = 0.5\ \rho\ Cd\ A\ V2$ (Cd value is 0.5 for frontal area A=0.7 m^2)
$= 0.5 \times (1.2) \times 0.5 \times 0.7 \times 16.67^2$
$= 58.35$ N (ρ is density of air 1.2 kg/ m3)

Total Force on the Vehicle is, F = Fh+ Fr + Fd = **105.06 N**

Power required for propulsion, P = F*V = 105.06*16.67 =**1752 Watt**

4. ELECTRICAL SYSTEM

The Electrical system consists of the following components:

1. Motor(BLDC)
2. Battery
3. Controller
4. Charger
5. Converter

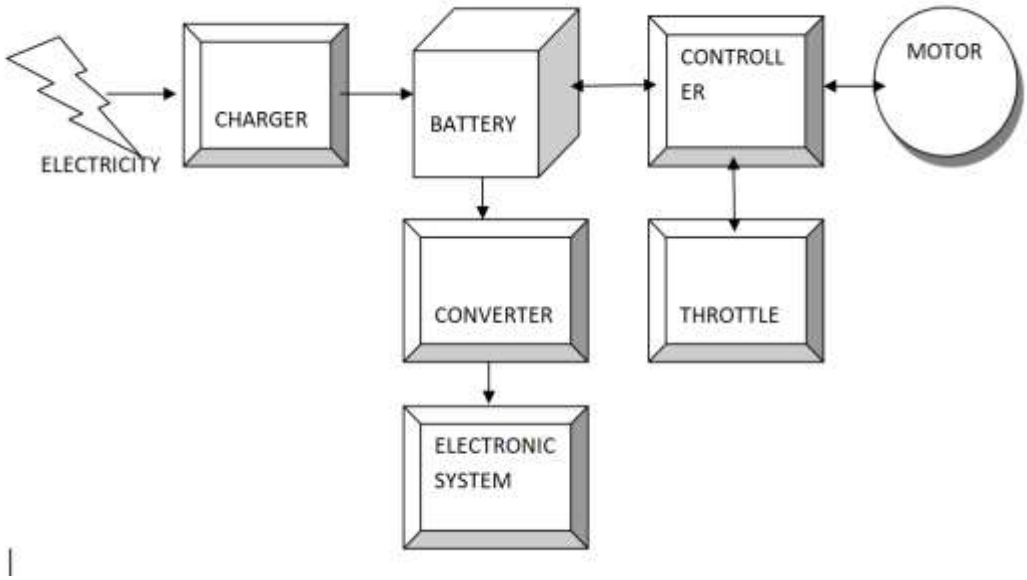

Fig. 1 *Electrical System*

4.1 Motor

Motor is an electromechanical component that is used to convert electrical energy into mechanical energy. Motor is classified into 2 types those are AC motor and DC motor.
AC motor requires Alternating Current whereas DC motor requires Direct Current as input.

DC motor is further divided into 2 types those are Brushed DC motor and Brushless DC motor.

Brushless DC motor (BLDC motor) is commonly known as synchronous DC motor or electronically commutated motor.

Fig. 2 *BLDC Hub Motor*

BLDC motor is commonly used in electric scooters because it is lightweight and compact size and this motor does not have brushes which result in improving the durability of the motor.

4.2 Battery

Batteries are electrochemical devices that store energy in form of chemical energy and convert it into the form of electrical energy.

4.2.1 Selecting Right Battery

We have to consider some factors before selecting battery type those are:

- Energy density (Total energy stored per unit volume or unit mass)
- Power density (Amount of discharge of energy per unit volume or unit mass)
- Efficiency
- Safety
- Lifecycle durability
- Cost

SPECIFICATION	Ni-Cd	Ni-MH	Li-ion
Specific Energy (Wh/kg)	45-60	6-120	100-260
Energy Density (Wh/L)	50-150	150-300	250-700
Specific Power (W/kg)	150	260-1000	250-350
Charge/Discharge Efficiency (%)	70-80	65	80-90
Cycle Durability (cycles)	2000	200-2000	1200

TABLE 2 *Specification of different Batteries*

The above table shows that Lithium-Ion batteries have the high energy density, efficiency, energy density, and also it is light in weight, compact size which helps to determine the type of battery required i.e Li-on battery.

Fig. 3 *Lithium-Ion battery*

4.3 **Controller**

The main task of the controller is to gather the electrical energy from a battery and to deliver an appropriate amount of current and voltage to the hub motor.
It is also used to control the speed of the motor after receiving the input from the throttle.
A Controller is also responsible for multifarious operations like forward and reverse motion, torque alternation, starting and stopping of the motor, etc.

Fig. 4 *Electronic speed controller*

4.4 **Charger**

An Electric charger is a recharging device i.e used to charge the battery by providing electrical energy to it which gets stored in the form of chemical energy in the battery cells.

Fig. 5 *Electric battery charger*

5 PERFORMANCE ANALYSIS

5.1 Motor Requirement:

As the total power required to move the vehicle is 1752 watts. We have to rake a motor having power more than it.
So the power of the motor is 2000 watts.
The motor used here is BLDC Hub motor 48 volt 200 watt.

5.2 Battery requirement:

Watt hour = 2000 w.hr
Battery Watt hour required = 2000*(1+0.1)= 2200 w.hr
Voltage = 48 volt
Current in battery = 2200 w.hr /48 v = 45.83 A.h
The battery used here is a Lithium-Ion battery that has a capacity of 48 volts and 50 Amp

5.3 Charger requirement:

Battery watt-hour = 2200 w.hr
Preferred charging time = 3 hr
Therefore,
Wattage of charger = (Battery watt hour/ Preferred charging time) = 733.33 watt
Voltage of charger = 48 volt
Current rating of charger = (Wattage of charger/voltage) = 15 Amp
The charger used here is 48v/18Amp

5.4 Motor Controller Requirement:

The Controller used here is a 48V 2000W Electric Bicycle Brushless DC motor controller for E-bike and scooter.

6 CONCLUSION

With the increase in population, the use of automobile vehicles is also increasing day by day. As major vehicles are using petrol or diesel as fuel it causes environmental pollution by the exhaust gas. To overcome this problem we must have to adopt some other method. E scooter is a perfect replacement for gasoline engines as it is not causing any environmental issues sound pollution, air pollution. This vehicle can also be used in rural areas where there is no proper availability of petrol or diesel. With the rise in fuel price future of Electic vehicles is going to be very bright. This paper provides a basic outline of electric scooters, their components, and their requirement. The provided E-scooter has a Lithium-Ion battery with a capacity of 48v, 50Ah which can be charged within 3 hours up to 2200 w.hr and can run up to a speed of 60 kmph.

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