DESIGN AND FABRICATION OF ELECTRIC BIKE

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Abstract:

In the present scenario with enhanced technology which can fulfill the basic requirements in order to overcome the existing energy sources used in the automobile sector. Thus the paper highlights on design and fabrication of electric bike where the electric energy is supplied by using lithium ion batteries. The work aims to attempt to fabricate an electric bike which posses optimal characteristics of a city commuter bike. The performance of the bike is tested by practical testing such as acceleration test, speed test and economy test. To ascertain the various characteristics a power train has been designed with an appropriate chassis.

KEY WORDS: Lithium ion battery, Electric bike, City commuter bike, Electric power train

I. INTRODUCTION

Motor cycle suits greatly for various purposes like commuting, cruising, long drive, sports including racing and off road riding the large number of automobiles are used around the world which has caused and continues to cause impact on the environment which are harmful to human life. IC engine bike's exhaust emissions contains oxides of nitrogen (NOx), Carbon monoxide, unburned hydrocarbons, sulphur oxides and carbon dioxide particulate matter which cause air pollution and global warming. Due to emission of such gasses there is a great impact on living beings which causes serious health problems. An Electric bike is one which is propelled by electric motor, rather than traditional petrol engine. The electric motor is powered by rechargeable batteries. Thanks to new technologies the electric vehicle industry is growing rapidly. This has led Electric bikes which can go further per charge, for less cost than traditional fuel powered vehicles. Battery electric vehicles use electricity, which is stored in a battery pack to power an electric motor and power's the wheels. When depleted, the batteries can be recharged using charging unit, similar to charging a mobile phone. Due to their sustainability and cheaper running costs, electric vehicles are likely to be the way of future. Electric bikes are also cheaper to maintain as they have less moving parts so running them could be lot cheaper. Electric bikes are charged using mains electricity therefore they show a significant reduction in greenhouse gas emissions of around 40% compare to IC engine vehicles. Pure Electric vehicles themselves have zero emissions therefore the air quality in cities should improve. The current road transportation is responsible for significant amount of emissions of nitrogen oxides. The impact on human health is likely to be reduced within urban areas due to the fact that most of the electric bikes are zero emissions at the point of use.

II. Components of Electric Bike

This section provides insight information of the various components involved in fabricating the vehicle.

2.1 Frame

The chassis serves as a frame work for supporting the body, various power train components and suspension, the chassis holds all components together while driving and transfer all vertical and lateral loads, caused by acceleration and braking through suspension and wheels hence the chassis is considered as most crucial element in an automobile[1].There are majorly five types of frame namely backbone frame, single cradle frame, double cradle frame, perimeter frame and trellis frame. Out of which trellis and perimeter frame are the two that can be considered for better performance of the bike. The research conducted from motor cycle racing suggest that a bike's rigidity improves if the steering head and swing arm pivot point are joined with shortest distance possible and this condition can be achieved in a perimeter frame. The perimeter frame has two beams connecting the steering head to swing arm pivot point, these beams are constructed to be light in weight. But stiffness of the frame is not compromised in order to withstand the different forces that act on the frame while riding the bike.

2.2 Motor

Brush Less DC motor, as the name indicates no brushes are used for commutation instead it is commutated electronically. BLDC motor as shown in figure 1 has been opted by considering its advantages over other motors[2]. They are the most suitable motors for electric bikes as they have characteristics such as

- High power to size ratio.
- It can provide high torque from the beginning.
- Long operating life.
- No real time pollution.

Figure 1- BLDC motor

The selected motor has following specification:

- Power: 6 hp nominal and 18hp peak
- Voltage: 48V
- Speed: 4000 rpm
- Torque: 14Nm continuous and 43Nm peak
- Cooling: Air cooled

2.3 Controller

A HALL active controller has been chosen which is suitable for the selected motor. The BLDC motor is controlled electronically, which is done by the HALL active controller by sensing the position of rotor through HALL sensors which are placed at particular positions along the inner circumference of the stator. The figure 2 shows the controller used.
Controller model: KLS7212MC

Figure 2- Controller

The selected controller model can support BLDC motors of

- Voltage：24 – 72V
- Maximum current: 180amps
- Maximum RPM :15000

2.4 Battery

In order to ascertain the basic requirements of the electric vehicles such as service life, capacity, cycle life and high energy density which cannot be met by lead acid batteries, hence selection of appropriate battery type place an vital role[3].

Lithium ion batteries have longer life span than other type of batteries, also it has high energy and high power density. The cost of Li-ion batteries can reduce more likely because of mass production [4]. Lithium ion cell model SAMSUNG INR18650-13Q has been chosen because of its high discharge capability. The Cell has capacity of 1300mah, nominal voltage of 3.6V and maximum voltage of 4.2V. 14 cells of this kind are connected in series to get required voltage to supply power to the motor and 13 of these series packed stacks are connected in parallel as shown in figure 3 to increase its capacity.

Figure 3- Battery pack

2.5 Battery management system

Battery management system monitors and reports all data regarding charge and discharge of the battery pack, it prevents over discharging, over-current, over-temperature and under-temperature which in turn increases cycle life of the cells [5]. BMS balances the potential of any series of cells which go beyond or below the pre set value. BMS as shown in figure 4 will monitor different parameters such as voltage, temperature, state of charge, state of health, state of power, coolant flow and current.

Figure 4- Battery Management System

III. Design

3.1 Design of transmission

The calculations in designing the transmission is shown in the below section

- Objective speed – 100kmph
  (22.77m/s)
- Wheel dimensions
  Rim diameter – 43.18cm or 17 inches
  Aspect ratio – 130/70
  Width-130mm
  Tire diameter 52.28cm
- Circumference – 2*pi*r ………………………………………. 1
  2*pi*26.14
  164 cm(1.64m)
- Motor maximum RPM- 4000

Calculation of RPS (revolution per second)
1 revolution – 1.64m
? - 27.7m/s
By interpolation the unknown RPS is determined as 16.89(1013rpm).

- Gear ratio
  45/14 = 3.21 = 4000/N2
  N2 = 1246rpm
  So by comparing N2 (1246) with required RPM (1013) the rear wheel can spin more than 27.77m/s which is more than 100km/hr.

IV. Mountings

4.1 Controller mounting using L clamp on to frame

Four L – clamps are used to mount the controller firmly to the frame. One of the L-clamp is CAD modeled as shown in figure 5 and stress analyzed to determine its factory of safety.

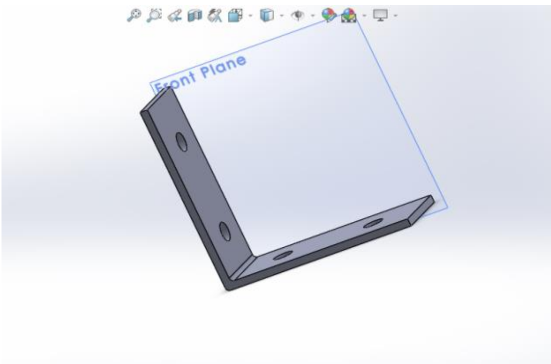

Figure 5 - 3D model of L clamp

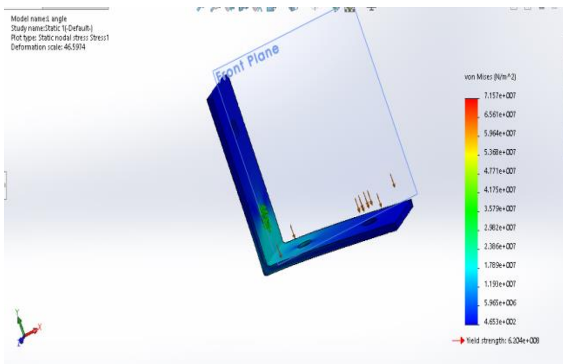

Figure 6 - Analysis of control mounting using solid works

Figure 6 shows stress analysis of the L – clamp in which mass of the controller itself is the only force acting on the clamp.

4.1.2 Parameters for stress analysis

Force is applied on a internal face of the clamp
Mass of controller being 1 kg, thus the force is 1*9.81 =9.81N
As there are 4 clamps the force is distributed to all 4 clamps equally, thus force on each clamp = 9.81/4=2.45N.
The material of the clamp is alloy steel with properties:

- Tensile strength: 758 -1882MPa
- Yield strength: 366-1793MPa
- Percentage elongation: 4-31%

The opposite face of the force applied face is fixed. And the structure is fine meshed and simulated, optimum results were obtained.

4.2 Battery mounting frame

- Battery pack is mounted using a frame constructed of L angles
- L angles are cut and welded as a frame to accommodate the battery pack as shown in the (fig.7)

Figure 7 - Battery Case

4.3 Motor mounting using steel plates

- Motor is mounted using steel plates as shown in figure 8.
- Mild steel plate of thickness 6mm is drilled at mounting points and required groove is provided for shaft bearing resting
- Stress analysis of motor mounting using solid works is made as shown in figure.9

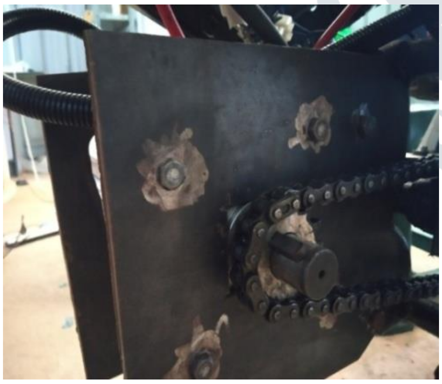

Figure 8- Motor mounted on ms plate

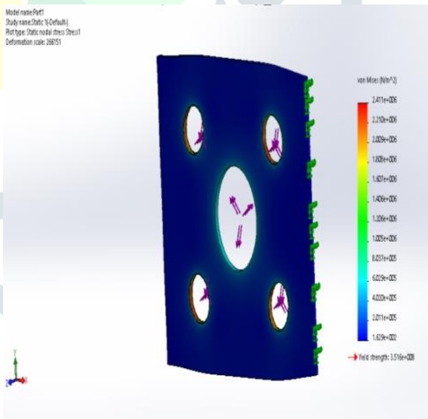

Figure 9- Stress analysis

4.4 Final assembled view

After all the components are mounted to the chassis the final image of the bike is as shown in the figure 10

Figure 10: Final image of the bike

Specification sheet

Table 1**:** All major specification of the bike is tabulated in the table below

Sl no.	Particulars		
	Motor		
1		Type	BLDC
2		Power (nominal)	6hp
3		Power (peak)	18hp
4		Torque (continuous)	14.3Nm
5		Torque (peak)	43.93Nm
6		Speed	4000rpm
7		Cooling	Air cooling
	Controller		
1		Model	KLS7212MC
2		Max current	180amps
3		Voltage	24-72V
	Power system		
1		Power pack	Lithium ion cells
2		Maximum capacity	0.98kWh
3		Charge time	1hr 45minutes
	Drive train		
1		Transmission	Clutch less direct drive
2		Final drive	45T/14T, Chain drive
	Chassis		
1		Frame	Perimeter frame
2		Front tire	100/80, tubeless
3		Rear tire	130/70, tubeless
4		Front and rear wheel	17”
	Suspension		
1		Front	Telescopic with anti friction brush
2		Rear	Nitrox monoshock absorber
	Brakes		
1		Front	Ventilated disc, 240mm
2		Rear	Drum, 130mm
	Dimension		
1		Wheelbase	1363mm
2		Saddle height	807mm
3		Rake	24^o
4		Trail	1inch
5		Length	1883mm
6		Width	804mm
	Economy		

1		Cost to recharge	Rs 1.5
2		Range	10 to 12km
3		Cost per kilometer	Rs 0.15 to 0.125

V. Results and discussion

5.1 Results

The bike has been tested on roads and the obtained results are tabulated

- The bike is found optimum for city commuting.
- The bike can reach a maximum speed of **85 kmph**.
- Range of the bike on full charge is **10 to 12 km**.
- Charging time of the power pack is **1 hr 45 min**.

5.2 Discussion

The fabricated bike has optimal characteristics to satisfy the need of city commuting without causing any real time pollution and can easily cruise with a speed of 50 to 60kmph. The top speed achieved by the bike is 85kmph whereas the objective was to achieve 100kmph. This is because the Battery Management system limits the current to 100amps from the battery supply, replacing the BMS that can allow more current of about 120 to 150amps can enable the bike to have the required speed and also it enhances acceleration of the bike.

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