Design and fabrication of lithium ion battery pack pedal assistance electric bike

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ABSTRACT

This paper presents the design and fabrication of electric bike model, recent days the fuel cost goes on hike day by day, the government is supporting the alternating fuel bikes to avoid the depletion of fuels and avoid environment air pollution finally global warming and this makes the idea and improving the existing electric bike. In our project includes the design of prototype model and fabrication of 48 V - 24AH lithium ion battery, less charging time, improved weightless model and 750 Watt BLDC electric motor driven pedal assistant electric bike.

Keywords *– 48V 24AH lithium ion battery pack, 750 Watt BLDC electric motor, 30 AH DC controller, etc*

I. INTRODUCTION

The present day scenario the fuel cost goes on hike day by day, the government is supporting the alternating fuel bikes to avoid the depletion of fuels and avoid environment air pollution finally global warming, around 93% of today's automobiles run on petroleum based product, which are estimated to be depleted by 2050. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere. Despite recent efforts to improve the alternating fuels for transportation.

This project proposes a motorcycle which has dual sources. The motorcycle consists of two working power sources that are pedaling and electrical power driven BLDC 750 watt motor.

1. Existing models

Currently electric gearless bikes have taken over the trend in the Indian market as per eco-bikes are concerned. Hero has released a wide range of scooters that run on electric motor which is powered by chargeable batteries. They have a top speed of 40/50 km/hr. They cost from Rs.20000 to Rs.40000. [1]

1.2 Drawbacks in Existing models

- They work only on a single principle (electric only), does not have dual sources where even a pedal assistance can be used for fastertravel.
- They can be run only about 60Kms percharge.
- They cannot generate enough power to move on hilly or elevatedroads. [3]

The comparison of different models are shown below [2]

Brand Name	**Pulsar 220F (Petrol bike)**	**Abhi**	**V60**	**Angel**	**E-trendy**	**E-star**
Cost of vehicle(in Indian Rs)	82,000	38,000	33,000	20,000	26,500	30,000
Top speed(kmph)	144	25	25	25	25	25
Range (in kms)	44 km/l 15 ltr fuel tank (44*15=660kms)	50	55	45	50	50
Full charging time(Hrs)	Not applicable	8-10	8-10	8-10	8-10	8-10
Battery Watts	Not applicable	250	250	250	-	250
Type of Battery: (Lead or Lithium ion,etc)	Not applicable	48V 12Ah	60V 12Ah	36V 12Ah	48V	48V 20Ah
Carrying capacity(in kg): 100kg=1 person (1/2)	250 or 2 to 3 persons	75	100	75	140	100

Our model lithium ion battery pack made up of small lithium ion batteries with each of 1.2 volts arranged in series and parallel connections. i.e., 13 cells column in series, 9 cells in parallel rows, total 117 cells and The

battery capacity of 48 volts and currents of 24 AH with nominal 48 volts and cutoff 35.5 volts. The motor capacity of 750 watts which runs with 48 volts nominal voltage runs at 3000 rpm, reduced to 1:6 ratio in motor, so 500 rpm speed, BLDC brush less direct current motor, which is controlled by 30 AH DC controller.

BLDC 48v 750 Watt Motor

Battery pack

II. DESIGN OF ELECTRIC BIKE

1. CAD drawing

The prototype model is prepared in solid edge software with proper proportions are shown below.

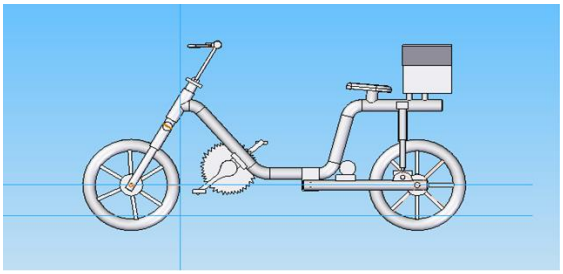


Fig 2 *Front view of electric bike*

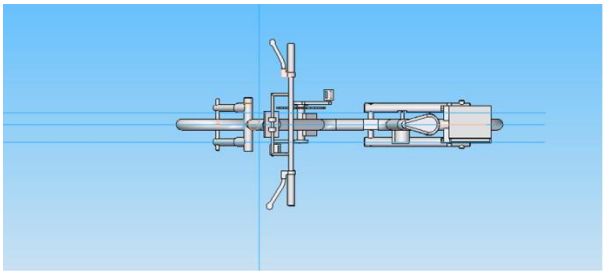


Fig 3 *Top view of electric bike*

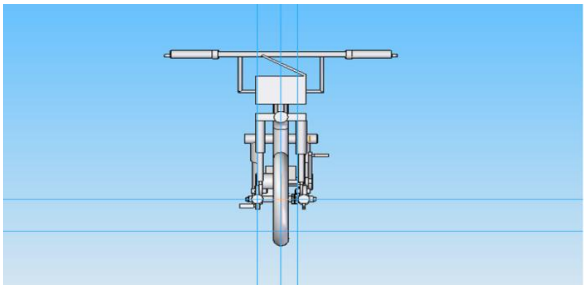


Fig 4 *Right view of electric bike*

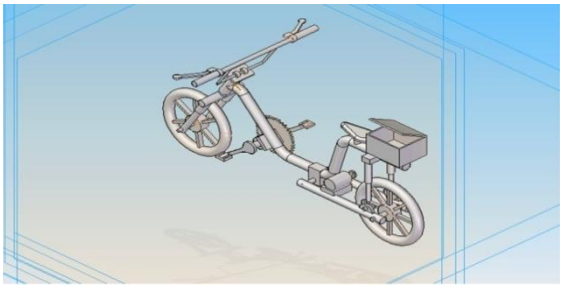


Fig 5 *Isometric view of electric bike*

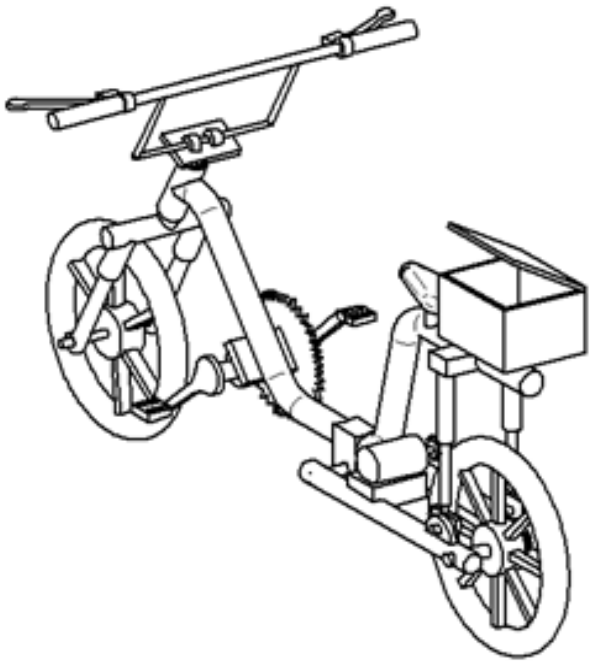


Fig 6 *2D drawing of isometric view*

2. Design Calculations

Design of spring:

Assumed data

Maximum load on spring F2=1700N

Minimum load on spring F1=1200N

Total maximum weight W=105kg (bike + person)

The axial deflection of spring for the load range is y=6mm, spring index C=5

(τ) Permissible shear stress=420Mpa

(G) Modulus of rigidity=84Mpa

Design calculation:

Maximum deflection Y2=(y*F2)/(F2-F1)

= (6*1700)/(1700-1200)

Y2=20.4mm

Diameter of wire (d):

Shear stress= (8*F2*D*K)/(πd^3)

K= (4C-1)/(4C-4)+(0.615)/C

= (4*5-1)/(4*5-4)+(0.615)/5

K=1.3105

C=D/d=5

D=5d

420=(8*1700*5d*1.3105)/(π*d^3)

d=8.218mm

Standard diameter from table 20.12, d=8.5mm

Diameter of coil:

Mean diameter of coil, D=5d=5*8.5=42.5mm

Outer diameter of coil, Do=D+d=42.5+8.5=51mm

Inner diameter of coil, D_i =42.5-8.5=34mm

Number of coils

Y2=(8*F2*D^3*d*i)/(d^4*G*1000)

20.4=(8*1700*42.5^3*8.3)/(8.5^4*84*1000)

i=10.58=11

i=11 coils

Free length 'l'≥(i+n)*d+Y2+a

a=clearance 25% of maximum deflection

a=0.25*20.4=5.1mm

number of additional coils, n=2

lo≥(11+2)*8.5+20.4+5.1

lo=136mm

pitch, P=(lo-2d)/i=(136-2*8.5)/11=10.818mm

Required stiffness

Fo=F2/Y2=1700/20.4=83.33N/mm

Actual stiffness

Fo=(d^4*G)/(8ID^3)=(8.5^4*84*1000)/(8*11*42.5^3)=64.909N/mm

Total length of the wire

L=π*D*i=π*42.5*11=1468.69mm

Design of the Shaft:

$Mt=(\pi*d^3)/16*\eta*\tau_3$

$Mt=(9550*N)/n*10^3$

$Mt=(9550*0.75)/480*10^3$

$Mt=14921.875N\text{-}mm$

$\sigma ut=450Mpa$

$\sigma y=0.6\sigma ut$

$\sigma y=0.6*450$

$\sigma y=270Mpa$

$\tau y=\sigma y/2=270/2=135N/mm^2$

$\tau s=\tau y/FOS=135/2=67.5N/mm^2$, where FOS=2

$14921.875=(\pi*d^3)/16*1*67.5$

$d=10.403mm$

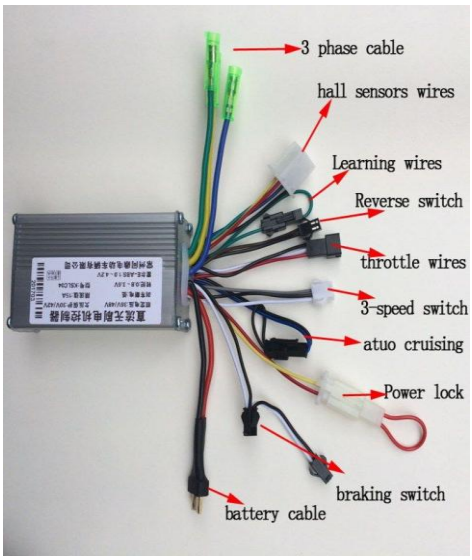
Design is safe.

3. DC MOTORCONTROLLER

Features:

1) Rated voltage:DC48V
2) Rated power: 750W
3) Rated current: 30A (limitcurrent)
4) Controller category: Brushless direct current
5) Applicable model: electric bicycle, electric scooter, electric vehicle,etc.

Fig 7 *DC motor controller*



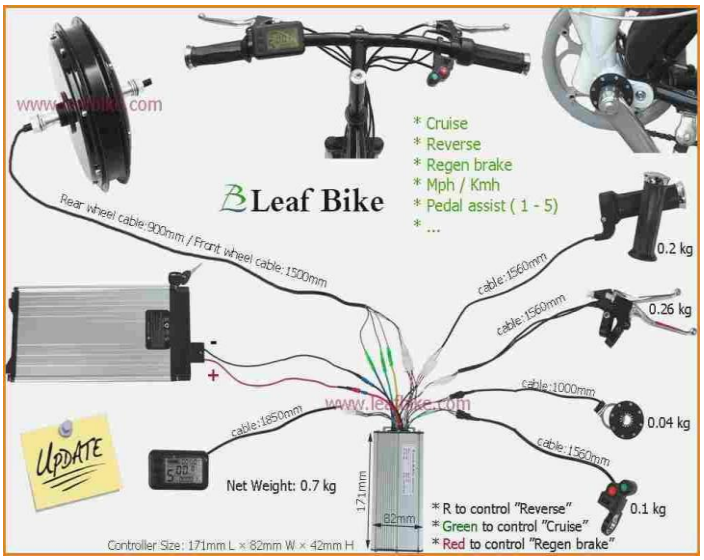


Fig 8 *Components of DC motor controller* **Fig 8** *Connections of DC motor controller*

III. FINAL ASSEMBLED MODEL

After all the electric connections and mounting of all parts , it was time to finish up the bike by fixing small elements like seat, accelerator, mudguards, etc. After all parts were assembled, we tested every single aspect of the bike to know if any changes were required and error proof the bike.

Elements like speed, pick-up, comfort and charging were tested.

(a)

(b)

Fig 9 (a) and (B) *Riding the electric bike*

IV. CONCLUSION

Successful fabrication of pedal assistance electric bike, the charging time of the battery pack is 3.5 hours, the bike gives 60 plus Kms per charge without pedaling.

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