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DESIGN FOR E-BIKE

K.KARTHICK RAJA [#1], S.SAM GILBERT RAJ [*2], K.VELU [*3], T.DINESH [*4], T.RANJITH KUMAR[*5]
[#1]*Student, Kings engineering college, Irungattukottai , Chennai-602117.*
[*2]*Student, Kings engineering college, Irungattukottai , Chennai-602117.*
[*3]*Student, Kings engineering college, Irungattukottai , Chennai-602117.*
[*4]*Student, Kings engineering college, Irungattukottai, Chennai-602117.*
[*5]*Assistant professor, Kings engineering college, Irungattukottai , Chennai-602117.*

***Abstract*—A E-Bike as known as a single seated simple bike. Our aim is to the design and analysis of a E-Bike chassis. The main intention is to do modelling and static analysis of E-Bike chassis. The Project is discussed about the design of an electric bike using the DC motor, controller and Chain Drive. The article of electric bike design as per the dimensions as possible to fabrications also we design our project to manage and reduce the environmental pollution. This project is implemented for the Vishnu E-moto Championship 2016. The design and analysis is solely based on the rule book issued by vemc2K16.**

I.INTRODUCTION

1.1 Introduction to Electric Bike

There are many motor sports in the world. Bikes, Cars, Formula one are examples of them. The drivers in these are very professionals and accurate. They can drive it very fast. But there are also motor sports which do not need professional drivers and need no great speed. The vehicles used are also very cheap. Such a motor BIKE is E-BIKE. They resemble to the bike but it is not as faster as ordinary bike and also cost is very less. The drivers in E-BIKE are also not professionals. Even children can also drive it. E-BIKE have 2 wheels. They are widely used in emission control in US and also they are getting popular in India. E-BIKE is a big craze to the Americans and Europeans. It is initially created in United States in 1950s and used as a way to pass spare time. Gradually it became a big hobby and other countries followed it. In India electric bike is getting ready to make waves. That means the engine in the electric bike is changed to motor and the batteries are used to supply current to the motor.

1.2 Objective of the Project

The design process of this single-person vehicle is iterative and based on several engineering and reverse engineering processes. Following are the major points which were considered for designing the vehicle

1. Endurance
2. Safety and Ergonomics
3. Market availability
4. Cost of the components
5. Standardization and Serviceability
6. Manoeuvrability
7. Safe engineering practices.

1.3 Frame Material Selection

- The material to be selected for frame should be feasible for manufacturing and strong enough to support all the components attached in frame.
- The Frame material should be less weight and highly efficient.
- The frame material should have less maintenance and corrosion resistance.
- The frame material should bear the impact and load.

II. ELECTRIC PROPULSION AND ENERGY STORAGE DEVICE

In the area of propulsion motor and other motor control technologies, methods to eliminate speed/position sensors, inverter current sensors, etc., have been under investigation for several years. The technological challenges for the electric motors will be light weight, wide speed range, high efficiency, maximum torque and long life. Most hybrid hardware subsystems and components with exception of energy storage devices have been matured to an acceptable level efficiency performance and reliability. As per the studies, the energy stored in the HEV storage unit is much smaller than that in the EV unit. It is also clear that the power capability of the batteries designed for HEVs is much higher than those designed for EVs. However, batteries for plug-in hybrid electric vehicles require both high energy density and high-power capability based on the driving requirements. The other significant technical challenges include higher initial cost, cost of battery replacement, added weight and volume, performance and durability.

III. DESIGN

3.1 Chassis

In order to reduce the weight and cost . Most of the problem is faced during turning due to lack of differential. Hence it allows ease of turning. In bike no differential is used which means power is transmitted to the rear axle through chain drive, and rear wheels rotate with same speed and equal torque is transmitted to both of them. So while taking a turn the outer wheel of the bike must be able to loose traction and skid over the road surface. This is done by slightly twisting the body of the bike during turning by providing castor angle to the front steering wheels. This castor angle brings the height changes in the front wheels and the outer rear wheel loses its traction allowing it to slip. The design of bike chassis is very complicated.

The chassis are generally made of square or round steel tubing's, or angle iron.

The frame is the main part of the chassis on which remaining parts of chassis are mounted. The frame should be extremely rigid and strong so that it can withstand shocks, twists, stresses and vibrations to which it is subjected while vehicle is moving on road. It is also called underbody.

The frame is supported on the wheels and tyre assemblies. The frame is narrow in the front for providing short turning radius to front wheels. It widens out at the rear side to provide larger space in the body. Frame can be called as skeleton of a vehicle, besides its purpose being seating the driver, providing safety and incorporating other sub-systems of the vehicle, the main purpose is to form a Chassis.

3.2 Types of Sections Used In Frames

Three types of steel sections are most commonly used for making frames:
(a) Channel section,
(b) Tubular section, and
(c) Box section.
In our project we selected tubular section frames which are high strength.

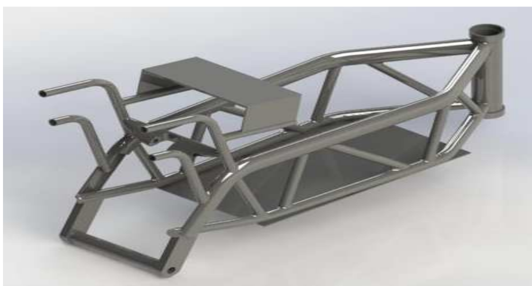

Fig no: 3.2 Frame Design

3.3 Components to Be Seated In Frame

1. Front wheel assembly
2. Rear wheel assembly
3. Brake system
4. Driver seat
5. Motor
6. Batteries
7. Transmission systems

3.4 Frame Dimensional

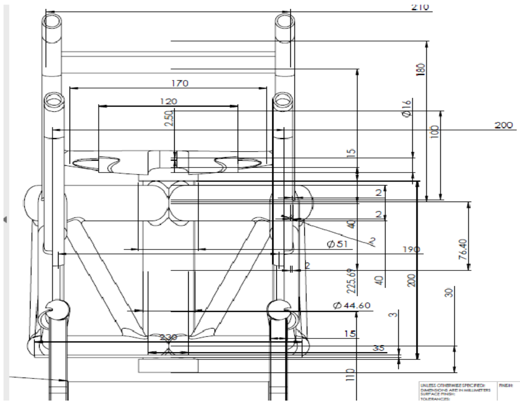

Fig no.3.2.Frame Dimensions

3.5 Front Wheel Assembly

The front wheel assembly has a Front wheel hub and has a King pin through which the front wheel is assembled in the vehicle. The front wheel has the bearing setup in their rims, so it just rolls with the acceleration of the rear wheel.

3.6 Rear Wheel Assembly

The rear wheel is assembled on the rear axle shaft directly. There is no bearing setup in the rear wheels. So it runs with the power of the motor which is transmitted to rear axle by chain drive.

Fig no.3.6 Rear wheel assembly

3.6 Tyres

Tyres are mounted on the rims of wheels. They enclose a tube between rim and itself. Air is filled at a designated pressure inside the tube. The tyre remains inflated due to air pressure inside tube. The tyre carries the vehicle load and provides cushioning effect. It absorbs some of the vibrations generated due to vehicle's movement on uneven surfaces. It also resists the vehicle's tendency to over steer or turns which cornering. Tyre must generate minimum noise when vehicle takes turn on the road. It should provide good grip with the road surface under all conditions.

3.7 Brake System

An excellent braking system is the most important safety feature of any land vehicle. We are selecting the disc brake system. The main requirement of the vehicle's braking system is that it must be capable of locking all four wheels on a track.

3.8 Motor

Motor is the heart of our vehicle. It is the drive unit. Motor is fixed rigidly with the help of motor bed with the frame. Smaller

Sprocket is connected with the motor shaft and power to the vehicle is given by the motor using chain drive. The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

3.9 Specification Of Motor

Volt = 36 V
Amps=21.3A
Watts= 600 W
Type = Permanent Magnet 36V DC motor

Fig no.3.5 PMDC Motor

3.10 Battery Specification

Nominal Voltage	=12V
Rated Capacity (20 hour rate)	=24Ah
Total Height	=175mm
Dimensions Length	= 100mm
Width	=100mm
Weight Approx.	=8Kg

3.11 Charger

Battery is to be charged by a charger. DC current is to be delivered by the charger to charge the batteries. Input given to the Charger is 220V AC supply. The charger is electric type or transformer type can be used for charging purpose.

3.12 Transmission System

Chain drives are popularly used in the automobile vehicles. We ausing transmission chain and sprockets. It is also called as roll chains. A roller chains provides a readily available and efficient method for transmitting power between parallel shafts. They can bused for long as well as short center distance. The transmission power from motor to the rear axle is made by the chain and sprocket assembly.

Smaller sprocket diameter =25mmOutside diameter =41.8mmLarger sprocket diameter =30mm

3.13 Transmission System

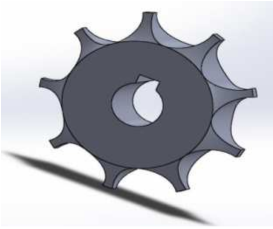

Fig no.3.7 Chain link

Outside diameter =150.71mm
Length of chain (L) =609.6mm
Center distance (a) =203.2mm

3.14 Transmission System

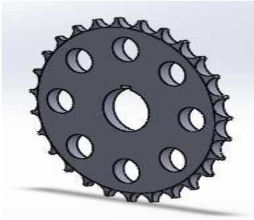

Fig no.3.8 Chain link

IV.DESIGN CALCULATIONS

4.1 Load Distribution

Frame weight	= 10kg
Seat and driver	= 80kg
Motor	= 10kg
Chain	= 5kg
Batteries	= 30kg

1. Reaction Force At Wheels Due To Frame, Seat And Driver

Total Load

F = (30×9.81) N + (100×9.81) N
=1275.3N

Distance from load to center of Rear wheel L_R= 520mm

Front wheels L_F= 560mm

$F \times L_F - R_R \times (L_R + L_F) = 0$

$R_R = FL_F / (L_R+L_F)$
$=1275.3\times560 / (1080)$
$= 661.266N$ (Reaction at rear wheels)
Reaction force front wheels
$R_F = F-R_R = 418.7N$
Reaction force at front wheel = 418.7N
Approx. weight of the vehicle =(1177.2/9.81)
=120 kg

4.2 Chain Selection

Available data:

Power	P=600W
Speed of driver	N_1=480rpm
Approx. center distance	a_0=190mm

1. Transmission ratio:
2. I =2
3. No. of teeth on driver sprocket: $Z_1=16$
4. No. of teeth on driven sprocket: $Z_2=iz_1=2\times16=32$
5. Standard pitch(p):
   a=(30 to 50)p
   Max.pitch $P_{max}=a/30=190/30=6.3$
   Min. pitch $P_{min}=a/50=190/50=3.8$
   But the minimum standard pitch is 9.525mm. (PSGDB 7.74)
6. 06B-1/R957 is selected.
7. Total load on driving side(P_T):
   1. $P_t = 1020N/v$
      N = 0.25kw
      $V = z_1pN_1/60\times1000$
      $= (12\times9.525\times3000)/(60\times1000)$
      =5.175m/s
      $P_t = (1020\times0.25)/5.715$
      =44.62N
   2. $P_c = mv^2$
      M = 0.41kg/m
      $P_c = 0.41\times5.715^2$
      = 13.4N
   3. $P_s = k.w.a$
      k=1 for vertical drive
      w=mg=0.41×9.81=4.02N
      a=0.15m
      $P_c=1\times4.02\times0.15=0.603N$

   Total load $P_T=P_t+P_c+P_s$
   =(44.62+13.4+0.603)=58.623N
8. Service factor (k_s):
   $K_s= k_1k_2k_3k_4k_5k_6$
   Where, $k_1=1$; $k_2=1.25$; $k_3=1$; $k_4=1.25$; $k_5=1.5$; $k_6=1$
   $k_s=(1\times1.25\times1\times1.25\times1.5\times1) =2.34$
9. Design load:
   $=P_T\times k_s$
   =(58.623×2.34) =137.17N
10. Factor of safety (FS_w):
    FS_w= Breaking load/Design load
    =(9100/137.17) =66.34
11. Working Factor of safety is more than recommended (18 from PSGDB 7.77), so the design is safe.
12. Check for bearing stress:
    $\Sigma_{roller} = (P_t\times k_s)/A$
    =(44.62×2.34)/22
    $=4.75N/mm^2$
    Induced stress is less than the allowable bearing stress ($13.7N/mm^2$ from PSGDB 7.77), So the design is safe.
13. Length of chain (L):
    No.of links $l_p=2a_p+[(z_1+z_2)/2]+[(z_1z_2)/2\pi]^2/a_p$
    $a_p=a_0/p=(190/9.525)$
    =19.95
    $l_p=(2\times19.95)+[(12+48)/2]+([36/2\pi]^2/19.95$
    =39.9+30+1.646
    =71.5 rounding up to 72mm.
    $L=l_p\times p$ =72×9.525 = 685.8mm
14. Center distance (a):
    $a=\{[e+\sqrt{(e^2-8M)}]/4\}\times p$
    $e=l_p-(z_1+z_2)/2$
    =72-(12+48)/2
    =42
    $M=[(z_1-z_2)/2\pi]^2$
    $=[(48-12)/2\pi]^2$
    =32.8
    $A = \{[42+\sqrt{(42^2-8\times32.8)}]/4\}\times9.525$
    =192.2mm
    Decrease in center distance for an initial sag
    = 0.01a
    = 0.01×192.2=1.92mm
    Exact Center distance
    =(192.2 - 1.92) = 190.2mm
15. Smaller sprocket diameter:
    $D_1 = p/[\sin(180/z_1)]$
    =9.525/[sin(180/12)]
    =36.8mm
    Outside diameter $d_{01}=d_1+0.8d_r$
    D_r=6.35 from PSGDB7.74
    D_{01}=(36.8+0.8×6.35) =41.8mm
    Larger sprocket diameter:
    $D_2 = p/[\sin(180/z_2)]$
    = 9.525/[sin(180/48)]
    = 145.63mm
    Outside diameter $d_{02}=d_2+0.8d_r$
    =(145.63+(0.8×6.35)) =150.71mm

4.3 Sprocket Dimensions:

Driving Sprocket Dimensions:

Diameter d1= 36.8mm
Roller seating radius (ri)
(ri)max = (0.505dr+0.0.069(dr)⅓
=(0.505×6.35+0.069×(6.35)⅓)
= 3.33mm
(ri)min = 0.505dr
= 0.505×6.35
= 3.21mm
(ri) = (3.33+3.21)/2
= 3.27mm
Roof diameter (Df)
Df = D-2r

= 36.8-(2×3.27)
= 30.26mm
Toooth flank radius (re)
(re)max = $0.008×dr (Z^2+180)$
= $0.008×6.35(12^2+180)$
= 16.45mm
(re)min = 0.12 dr(z+2)
= 0.12×6.35(12+2)
= 10.67mm
re = (16.45+10.67)/2 = 13.56mm
Tooth side radius (rx)
(rx) min = p= 9.525mm
Tooth width (bf)
bf = 0.93 b1 p ≤ 12.7mm
width b/w inner plates
bf1= 0.93×5.90 = 5.487mm
Tooth side relief (ba)
ba = 0.1p to 0.15p
= (0.1×9.25) to (0.15×9.525)
= 0.9525to 1.4287
= (0.9525+1.4287)/2
= 1.19mm

4.4 Driven Sprocket Dimensions:

Diameter d2 = 145.63mm
Roller seating radius (r1)
(ri) = 3.27mm
Root diameter (Dt)
(Dt) = D-2r
= 145.63-2×3.27
= 139.09mm
Tooth flank radius (re)
(re) max = $0.008 dr (z^2+180)$
= $0.008×6.35(48^2+180)$
= 126.18mm
(re)min = 0.12 dr (z+2)
= 0.12×6.35 (48+2)
= 38.1mm
Re = (126.18+38.1)/2
= 82.14mm
Tooth side radius rx = p = 9.525mm
Tooth width bt = 5.487mm
Tooth side relief ba = 1.91mm

4.5 Speed Calculations

No. of teeth in smaller sprocket = 16
No. of teeth in bigger sprocket = 32
Speed ratio = 3
Max speed of smaller sprocket = 480rpm
Max speed of bigger sprocket = 480 / 3 = 160rpm
Wheel circumference = πD = (π × 0.254)
= 0.798m
Distance travelled per rotation =0.798m
Distance travelled per minute = (0.798×480)
= 283.04m/min
Max speed of the vehicle = 28.3km/hr

4.6 Battery Calculation:

Motor Specification

Volt = 36 V
Amps =21.3 A
Watts = 600 W
Type =Permanent magnet 36V Dc motor

4.7 Battery Specification

Volt = 12 V
Amps = 21.3 A
Amp per hour = 24 Ah

4.8 Battery Charging Calculation

Charger 12V , 6 A
Charging time =$2×B_{Ah}$/ C
= 2×21.3/6
= 21mins.
Battery will be full charged in 21 mins.

4.9 Battery Discharging Calculation

Motor consumption at initial pick up
= 13 A × 6 = 780 Ah
Battery delivery = 24 Ah
Motor running = 24/780=0.03hrs
=3.07mins
Motor consumption at running = 2 A60
= 120 Ah
Motor running = 24×4/120=2 hrs
=120 mins.
Motor runs for 120 mins with full charge.

4.10 Distance Travel By The Vehicle At Full Charge

Max speed of motor =480rpm
Max speed of rear axle shaft = 480 / 3
= 160rpm
Wheel circumference = πD
= π × 0.254
= 0.798m
Distance travelled per rotation = 0.798m
Distance travelled per minute = 0.798×1000
= 79.88m/min
Max speed of the vehicle = 35.91km/hr
Distance travel by our vehicle at full charge
= 598.5m / min × 21 min
= 12.568 Km
Vehicle runs 12.568 km at full charge

4.11 Drive Wheel Torque Calculations

Gross vehicle weight (GVW) = 100kg
Weight on each drive wheel (WW) = 63.2kg
Radius of wheel/tire (Rw) = 0.254m

Desired top speed (Vmax)=35km/hr =9.97m/s
Desired acceleration time (ta) = 10sec
Maximum incline angle (α) = 5^0
Working surface = concrete (good)
TTE [N] = RR [N] + GR [N] + FA [N]
Where:
TTE = total tractive effort [N]
RR = force necessary to overcome rolling resistance [N]
GR = force required to climb a grade [N]
FA = force required to accelerate to final velocity [N]
The components of this equation will be determined in the following steps.
Step 1.
RR = GVW xCrr
where:
Crr = surface friction (0.01 for good congreat)
RR =105 ×0.01
=1 N
Step 2.
GR = GVW x sin(α)
=100 × sin (5)
=8.71 N
Step 3.
FA = GVW x Vmax / (g x ta)
=(100×9.87) / (9.18×10)
=10.06 N

Step 4.
TTE= RR + GR + FA
=1.00 + 10.06 +8.71
=19.77 N

Step 5.
Tw = TTE x Rw x RF
Where,
RF = “resistance” factor(1.1)
T_w = 19.77 ×0.254
= 5.021 N
Step 6.
MTT= Ww x μ x Rw
Where,
μ = friction coefficient between the wheel and the ground (~0.4 for plastic on concrete)
MTT = 63.2 × 0.4 × 0.254
= 6.42 N-m
T_w< MTT × 2

The total wheel torque calculated in Step Five is lessthan the sum of the Maximum Tractive Torquesfor all drive wheels, so slipping will not occur.

Min. Braking Time and Distance:
Mass of the vehicle m =120 kg
Speed of vehicle v = 9.97 m/s
Rotational speed of rotor n_r = 480rpm = 12.5 rev/s
Kinetic energy of vehicle KE = ½ mv^2
=1/2 ×100 ×9.97^2 =9.62KJ
P = F_R ($2\pi r_r$) n_r
=5643.67 (2π × 0.075) 12.5 = 33.2 KW
Braking timet = KE / P = (9.62 / 33.2)
=0.29 sec
Deceleration a= v / t = (9.97 / 0.29)
=34.4 m/s^2
Stopping distance s = ½ at^2 = (½ × 39.88 × 0.29^2)
=1.44 m (values under optimum conditions)

V. CONCLUSION

The Electric bike which is designed and analyzed will be less weight, more strength, highly efficient, Eco-friendly, comfortable, low maintenance, high speed and torque. This project aims at the development of Electric vehicles. This study comes up with the development of Electric vehicles. Best alternative fuel vehicle are developed with the best outcome of efficient and good eco-friendly. The future development of our project is under grown until it fulfills the needs of users.

VI.FUTURE SCOPE;

This design should be developed more to make the Electric vehicles more efficient and to manufacture this design highly efficient and feasible manner. This electric vehicle should be designed as a hybrid Electric vehicle in future developments.

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