Design and Fabrication of Hybrid Mini Scooter

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Abstract The present work intends to study and create a solution to be used as a means of transportation adapted to the metropolis environment. This solution lies in projecting and building a prototype of an electrically assisted power vehicle, mainly directed to be used around the Last mile concept. Nowadays there are plenty of two-wheeler scooters causing many problems. Some of major problems are pollution, traffic, and reduction of non-renewable energy resources etc. The main purpose of the project to create a eco-friendly portable automobile which is easy to handle to emit 0% emission. Manual pedalling was used as main power source to reduce emission and solved fuel consumption problem. One of the major issues is Battery charging. Hence, in pedalling, energies converted from mechanical to electrical, which was used to charge the battery. Scooter was modelled in Fusion 360, simulation was performed in ANSYS and fabricated model could be folded easily. The model was unique, light-weight foldable electric scooter and eco-friendly to use.

Key words: Scooter, mini scooter, design, ANSYS, and fabrication;

1. Introduction:
Electrical vehicles are claiming a place in several industries, especially in the fields of transportation. The application of electrical motors in bicycles and cars opens up new possibilities and a large number of advantages. Electric motor vehicles are a concept to take into account in the present and even more in the future, as they can open new possibilities or even replace the possibilities given nowadays by the common internal combustion engines. It presents a very small ecological footprint, specially comparing with cars, once that they are less or virtually non-pollutant. Another feature that increases this variation are the considerable different occupation rates.

Cars usually present occupation rates around 1 and 2 persons, representing 20 to 40 percent of its total capacity while bicycles employ its entire capacity rate, increasing efficiency and reducing the footprint. Kumar, et al. 993 [1] provided clearly information on Electric vehicle through their study. They powered the vehicle with Nickel metal battery and got a range of 100km between the recharges. When they replaced with polymer batteries, its range increased exponentially to 300 km, when they were implemented the power kits on existing bicycles, which had solved the many issues like cost, pollution. Thus help to the commutator of low range distances like medicine suppliers, education and premises in rural and urban areas. They used DC motor and motor controller for power controls and...
they were suggested and developed the controller configurations. Henry M. and Gannon, 2016 [2] study relates to multi-wheeled vehicle but not resisted to a bicycle. It consists of a standard conventional bicycle with multi-speed transmission, plus an electrical generating system and a solar charging arrangement. The arrangement was powered by combination of motor and pedaling, coupled in such a way that they provided power at any instance. Electrical System consists of DC hub motor, lead acid batteries and a hand lever operating a throttle means. Regenerative braking arrangement was studied to utilize the arrangement to generate energy that was charged the battery [3, 4].

One usual problem associated with the use of electric scooter is battery charging, it takes lot of time for full charging of the battery for that reason a model of hybrid concept is introduced in the present study. Battery is to be charged with help of pedalling to some extent and can also provide assistance to the rider through the journey, to help rapidly achieve speed or to let the rider move along the way. This concept can reveal to be also very beneficial to people with locomotion difficulties, as it can transform and upgrade a common scooter or similar vehicle to meet people’s needs, helping them on transportation and increasing its mobility [5-9].

The major objective of this study is to consider the best alternatives to be used as a daily mean of transport to commute to effort. We should come up with a solution able to solve the problems inherent to the common urban means of transportation, as public transports, private cars or common bicycles; a new approach is adopted in the present study. Thus create a better alternative for this specific purpose, for such reason, the best alternatives is considered and is studied from the several hypotheses for an electrically assisted vehicle. This study also has the end of building a fully working prototype within the possibilities that are given; this is taking into consideration the time, capital available, access to building methods and materials among other constraints.

2. Materials and methods
2.1 Concept of Electric Bike (E-Bike):

An electric mini scooter is commonly known as E-Bike, which is as an integrated electric motor used for propulsion. Several types of e-bikes are existing in market, which have the small motor to assist riders pedal power.

2.2. Chassis design

The frame is the main component of a bike, it’s the component that connects all the other parts and where these are fitted in. But it isn’t just the component that connects all the parts, as it has extreme influence in the scooter performance, safety and nearly all aspects of the scooter.

2.3 Material selection

The most common material for the frame is used as the steel from the beginning of the any vehicle history, but there are several other ordinary alternative, such as aluminium alloys, titanium, carbon fibre and other composite materials. All the materials are having its own advantages, but the steel is most used one, due to high strength, relatively easy to work, cheap and reliable. Aluminium, in spite of its lower density compared to steel, is more difficult to work with and more expensive, Titanium, in spite of having a high strength to weight ratio and excellent corrosion resistance it’s even more expensive and difficult to machine than both steel and aluminium. The carbon fibre, it has the advantage that can adapt to virtually any shape but it needs constant care and maintenance. According to the properties which are depicted in Table 1, chosen the material of the frame is AISI 1018 steel. Figure 1 shows the modelling of the chassis.
Table 1: Comparison table between AISI 1018 and AISI 4130 material

| PROPERTIES              | AISI 1018 | AISI 4130 |
|-------------------------|-----------|-----------|
| Density                 | 7.8kg/    | 7.8kg/    |
| Yield Stress            | 392.25MPa | 799.803MPa|
| % Elongation at fracture| 10.83%    | 10.83%    |
| % Decrease in area      | 55.36%    | 30.57%    |
| Breaking Strength       | 355.736N/ | 751.745N/ |
| Elongation at break     | 24.130mm  | 28.730mm  |
| Brinell Hardness        | 120       | 197       |

Figure 1 Chassis

2.4. Components used in mini scooter
Main components used in hybrid mini scooter are motor, Lithium ion battery, hand throttle, bicycle chain, chains pocket, pedal, handle bar, disk rotor, brake lever, brake caliper, headlight, saddle, suspension, telescopic fork, wheels.

3 Theoretical Approach

Figure 2 shows the approach adopted in the present work.
4. Results and Discussion

4.1. Calculations

Power = 250 watt
Speed (N) = 360 rpm,
Voltage (V) = 24 V
Type of power transmission used: Chain Drive Reduction Ratio: - 1:2
\[
P = 2\pi N_1 T_1/60
\]
\[
T_1 = 60 \times 360 / (2 \pi \times 250)
\]
\[
T_1 = 6.63 \text{ Nm} \quad \text{N1/N2 = T2/T1; T2 = 360*6.63/180} \quad T2 = 13.2 \text{ Nm}
\]
\[
T_3 = 1.8 \text{ Nm}
\]
\[
T_4 = (360*1.8)/180
\]
\[
T_4 = 3.6 \text{ Nm}
\]
\[
N2 = 3000/2 = 1500 \text{ rpm}
\]
\[
V = N2 \times \text{circumference of rear wheel in meters}
\]
\[
V = (180 \times 3.14 \times 0.508)/60
\]
\[
V \text{ max} = 20 \text{ kmph}
\]
Here, \(P\) = Power at motor
\(N1\) = rpm at motor shaft = 360 \(N2\) rpm at wheel
\(T1\) = continuous torque at motor shaft,
\(T2\) = continuous torque at wheel shaft,
\(T3\) = peak torque at motor shaft
\(T4\) = peak torque at wheel shaft
\(V\) = velocity of the vehicle

4.2. Analysis Considerations and Assumptions
The velocity of vehicle before hitting = maximum velocity of car
The time of collision = 0.4 seconds
Mass of the vehicle = 80 kg;
Final velocity = 0;
\(a\) = acceleration;
Where \(V\) = initial velocity = 20 kmph

\[
= 20 \times 5^{\frac{18}{18}} \text{ m/s} = 5.56 \text{ m/s}
\]
From laws of kinematics \(v = u + a \times t\)
\(0 = 5.56 + a \times 0.4\)
\(A = 13.9 \text{ m/s}^2\) (RETARDATION)
From Newton's law
\(\text{Force} = \text{Mass} \times \text{acceleration};\)
\(\text{Force} = 180 \times 14\)
\(\text{Force} = 1120 \text{ N}
\(G\)-Force = Force/(mass x acceleration due to gravity)
\(G\)-Force = 1120/(80 x .8)
\(G\)-Force = 1.42
4.3 Front impact test

Force = 4G,

Factor of Safety = Yield strength / working load

FOS = 440/354.5

FOS = 1.24

From Figure 3 and Figure 4, it was observed that maximum Equivalent stress was obtained at 354.52MPa and deformation is 5.2688mm for front impact test.

4.4 Rear Impact Test

We considered the situation as in the previous case where opponent car is trying to overtake our kart and hit ours. Force = 3G FOS = 443/173 = 2.5

From Figure 5 and Figure 6, it was observed that maximum Equivalent stress was obtained at 73.305MPa and deformation is 0.32363mm for rear impact.
4.5 Side Impact Test

We considered 2G force

\[ \text{Force} = 2G \]

\[ \text{FOS} = \frac{440}{264.42} = 1.6 \]

![Figure 7. Side impact Equivalent stress](image1)

![Figure 8. Side impact Deformation](image2)

From Figure 7 and Figure 8, it was observed that maximum Equivalent stress was obtained at 264.23MPa and deformation is 4.6505mm for side impact.

![Figure 9. Front view](image3)

![Figure 10. Side view](image4)

![Figure 11. Top view](image5)
5. Conclusions
The study was thought to simplify and ease the transport in big city environments in general, yet, it was mainly aimed to be applied in the “Last mile” concept. It was made a study on the market of electrical bikes which revealed a large and exponential growth of sales of electrical bikes in the last years. In this study, the designing was done in Fusion 360 and parts were analyzed by applying some boundary conditions in ANSYS software. By applying static structural loads FOS was calculated at each front, rear and side of the bike and theoretical calculation was also performed. A future work and development of this project would be the improvement and reinforcement of the design as well as considering other alternatives, possible better suited, to hold the bike in the folding position.

References

[1] Kumar Binod, H. Oman, Power control for battery-electric bicycles, Aerospace and Electronics Conference, 1993. Proceedings of the IEEE 1993, National. IEEE,1993.
[2] Morchin, William C. Battery-powered electric bicycles, North con/94 Conference Record. IEEE, 1994.
[3] K. S. Yun, FOLDABLE BICYCLE. Seoul Patent US 2011/0193313 A1, 11 Aug2011.
[4] L. Ford Global Technologies, FOLDABLE ELECTRIC BICYCLE. MI/US Patent US 9,469,364, 18 Oct2016.
[5] Dumitrache et.al., E-bike electronic control unit, Design and Technology in Electronic Packaging (SIITME), IEEE 22nd International Symposium for. IEEE, 2016.
[6] J. Dill, G. Rose, 2012 Electric bikes and Transportation policy Insights from early adopters, Transportation Research Record: Journal of the Transportation Research Board, 2, 1.
[7] Henry Gannon, Electric and pedal driven bicycle with solar charging, patent no. 5316101, May 311994.
[8] F. L. Maestrelli, Bicycle frame optimization by means of an advanced gradient method algorithm, Technical report, Studio Maestrelli, 2008.
[9] P. D. Soden et.al. 1986 Loads, stresses and deflection in bicycle frames. Journal of strain analysis, 21(4) 185-195.