

# Designing and Construction of E- Foldable Bicycle

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**Abstract** - A bicycle, also called a cycle is a human-powered, pedal-driven, single-track vehicle, having two wheels attached to a frame, one behind the other. E-foldable Bicycle is basically an environmentally friendly and economical mode of personal transportation powered by human force as well as electric power, and the use of bicycles as a mode of transportation is the most promising step toward developing green transportation. A high-priority requirement for urban bicycles is not only their riding performance but their availability in compact sizes, which can be achieved by incorporating a feature in their design that facilitates them to be folded into portable sizes. And also due to its main feature of electric drive it has ability to travel at a controllable speed of 15-20kmph to a great distance of nearly 10 km [Approx.] which is beneficial for those people which are not regularly drive the bicycle.

Folding mechanism vary, with each offering a distinct combination of folding speed, folding ease, compactness, ride, weight, durability and price. Here basically we are using a hinged type mechanism which have to lock manually. And to make the bicycle of high strength and durability we are going to use hollow shafts of mild steel having to construct a bicycle frame. E-Foldable Cycle is not only beneficial for environment but is also very human friendly, and to drive it by electric power here we use a D.C motor of 24V which is run with the help of two 12 volts maintenance free battery.

**Key Words:** Mild steel, D.C motor, Battery, Bicycle, Folding mechanism.

## 1. INTRODUCTION

### 1.1 Background of Bicycle

A bicycle is a human-powered conventional type of personal transportation, having two wheels attached to a frame, one behind the other driven with the help of pedal. Bicycles were introduced in the late 19th century in Europe, and by the early 21st century, more than 1 billion were in existence at a given time. From the beginning and still today, bicycles have been and are employed for many uses. In a utilitarian way, bicycles are used for transportation, bicycle commuting, and utility cycling. It can be used as a 'work horse', used by mail carriers, paramedics, police, messengers, and general delivery services. Military uses of bicycles include communications, troop movement, supply of provisions, and patrol.

### 1.2 E- Foldable Bicycle

An E-foldable bicycle is a bicycle designed to fold into a compact form, facilitating transport and storage. When folded, the bikes can be more easily carried into buildings, on public transportation and more easily stored in compact living quarters or aboard a car, boat or plane. The combination of electrical energy and human force make this bicycle unique and feasible.

By adding an electric drive in this bicycle along with mechanical drive we can ride this bicycle to approx. 10 km with the speed of 15-20Kmph. In this bicycle here, we are using permanent magnet D.C motor has power of 250 W, along with the rechargeable maintenance free battery having voltage of 12volts each. The battery and motor are lighter in weight to easily carry. The main consideration of the bicycle is aspect of material used in design and fabrication of the bicycle is mild steel which makes it durable.

A hinge in the frame may allow the rear triangle and wheel to be folded down and flipped forward, under the main frame tube. Similarly, the front fork and wheel of bicycle allow to move backward under the main frame. Folding mechanisms consist of latches and quick releases, which affect the speed of the fold/unfold.

## 2. PROBLEM IDENTIFICATION

- The main problem with the conventional bicycle is that we cannot fold and carry it anywhere because some times when path is so much difficult or uneven surface is there, we are not able to lift the bicycle on our shoulder in that situation to reach our destination.
- The another most important problem in conventional bicycle is that we cannot able ride the bicycle to a large distance, because it requires so much stamina.
- Another important problem in conventional bicycle is that even if it is very slim or small vehicle but still there is a big issue of parking space in most of the urban areas. As in conventional bicycle there is no possibility of changing the shape it is some time difficult task to park a bicycle.
- Another important issue in conventional bicycle is portability we cannot carry the whole bicycle in an assembled form if we have space issue, we have to disassemble the whole bicycle and then we can carry it

to different places if our destination is so far from our location.

### 3. PROPOSED SOLUTION

- By using folding mechanism, we can easily fold and carry the bicycle to anywhere across the world. Due to this we eliminated this limitation which we found in conventional bicycle.
- To eliminate the human effort to ride the bicycle for a large distance we added an electric drive in the bicycle to travel long distance.
- To solve the parking issue which we found in the conventional bicycle we added folding mechanism so that we can store the bicycle in the boot space of car, inside the wardrobe, under the office table etc.

### 4. METHODOLOGY

- ❖ First of all, we read many research papers and journals which are present related to this topic and their different concepts.
- ❖ After that we think the different ideas which can make this concept of e- foldable bicycle more appropriate and different from the concepts proposed by previous authors.
- ❖ To study our own idea, we create a 3-D model of bicycle on CREO parametric to get an idea of how the whole mechanism of folding will work
- ❖ Then we make a 3-D model of electric motor and battery and merge it in the folding bicycle to understand the model more appropriately.
- ❖ To find out whether the model is successful or not we analyze the product in ANSYS software.
- ❖ After the design is successful, we decide to fabricate the model for that we choose mild steel as it has high strength and easily available and also on top of that it is economical.
- ❖ After fabricating the bicycle frame along with the folding mechanism, we test the model by riding it on road. For testing the bicycle, we choose the regular road having minor irregularities and potholes.
- ❖ Testing of electrical drive is done by monitoring the R.P.M obtain by the motor by the help of tachometer. As the road surface causes the friction while riding the bicycle the efficiency of motor is reducing to certain level.
- ❖ Also, several times the folding and unfolding of bicycle is done to check the durability of folding mechanism.

- ❖ During testing of model if any issues or defects are found in design or any other problem is found in model which affect the performance of bicycle modification is done in bicycle.

### 5. MATERIAL AND HARDWARE SELECTION

- There are several materials available in the market and each material has different mechanical properties such as yield strength, hardness, Young's modulus, Tensile strength etc. In this project we are using mild steel because of its availability as well as it is economical in comparison with other two and also having good strength and load bearing capacity and all its properties are full filling the requirement of the project. However, the other materials which are mention in the table are possible to use but to our objective of making it economical we prefer the use of **mild steel**.

Table- 1: Material

Material	Tensile Strength [GPa]	Young's Modulus [GPa]	Thermal Conductivity [W/m-k]	Hardness (500gm load) [B.H.N]
Al Alloy 6061-T6	0.25	68.2	151-202	95
Mild steel	0.44	205	46	126
Carbon Fibre	3.5	228	24	16.12

- The maintenance free battery that we are using in this project has sufficient capacity, consume less space, economic and therefore due to its excellent capacity it is the most preferable battery also we can use Li-ion and Li-polymer battery but due its high cost and less availability we prefer maintenance battery.

Table- 2: Battery

Type	Weight	Capacity
Li-ion	1.3 kg	10 Ah
Li-polymer	0.67 kg	7 Ah
Maintenance Free	2 kg	5 Ah

- In this E-foldable bicycle we are using permanent magnet brushed D.C motor to obtain the electric drive. The main reason of using this motor over brush less D.C motor is if during operation of motor will fail, we have replaced it with new as it is very difficult to repair and in most of the case it is impossible and also its initial cost is very high. By keeping this consideration P.M.D.C motor is appropriate.

**Table- 3: D.C Motor**

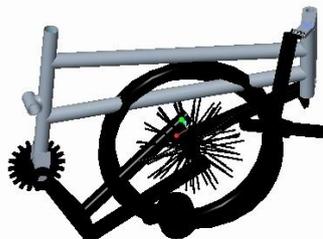
Type	Weight	R.P. M	Power [W]	Torque [N-m]
P.M Brush D.C. Motor	1.2 kg	400	250	22
Brushless D.C. Motor	0.45 kg	300	250	7-8

**6. DESIGN OF E- FOLDABLE BICYCLE**

- Un- Folded 3-D view of E-Bicycle



- Folded 3-D view of E- Bicycle



**7. ANALYSIS OF 3-D MODEL**

- Static structural analysis of the bicycle frame applying 980.6 N of load on frame.



**Fig No. 1**

**Normal stress value along x-axis**

Maximum	1.5327e6
Minimum	-2.7025e6

- Stress analysis of frame provided with folding mechanism while the hub of wheels is constrained.

Load on frame- 980.6 N.



**Fig No. 2**

Normal stress value along x-axis	
Maximum	1.0123e6
Minimum	-2.8908e6

➤ Analysis of frame which undergo total deformation.

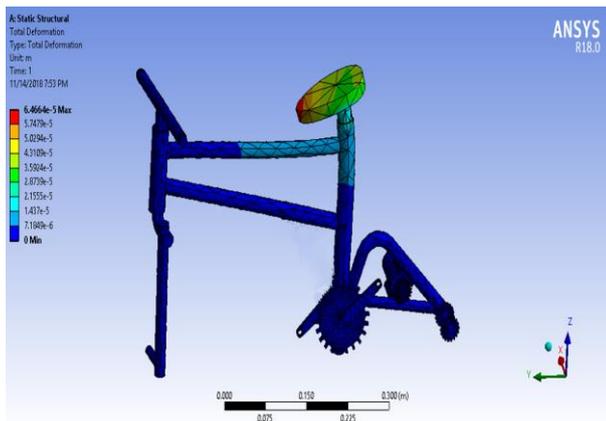


Fig No.3

Stress value on x-axis	
Maximum	5.7479e-5
Minimum	0

- ❖ In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials.
- ❖ For this project basically we use hollow shaft of mild steel having thickness of 3mm and diameter of 1 inch due to having great strength, large availability and less cost.
- ❖ After selecting the material, we start the fabrication of our e-foldable bicycle and according to design we start to cut and grind the material and prepare it for next process.
- ❖ After cutting and grinding process welding of bicycle frame is done. For welding purpose basically gas welding is used but for some minor areas electric arc welding is done.
- ❖ After the welding and finishing of frame and its sub component is done the folding mechanism is made and installed in the bicycle on its both front and rear end.
- ❖ After completing the main fabrication work of bicycle painting is done on the frame to prevent it from corrosion as well as to give it a great aesthetic look.
- ❖ After giving it a nice look at the end we installed the whole electric drive and unit in the bicycle such as battery, motor, controller, throttle, E-brake, headlight etc.

### 8. PROCESS OF MANUFACTURING



### 9. FOLDING MECHANISM JOINTS ON BICYCLE



Fig. 1 Fig. 2  
Front wheel folding Rear wheel folding  
Mechanism Mechanism



Fig. 3  
Handle bar column folding  
Mechanism

### 10. OBSERVATION OF E-FOLDABLE BICYCLE

During the practical observation it is found that due to difference in weight of rider the efficiency of e-bicycle get change. When the bicycle carrying the weight of 80 kg or greater than 80 kg its velocity gets reduced and similarly when weight of rider is between 55 Kg to 60 Kg velocity and traveling distance is also change. Also, the calculated time to fully charge the battery is not totally precise as it depends on the metered connection which gets fluctuate and sometimes shut down due to various reasons.

#### Images of E-foldable Bicycle

Un-folded View



Folded View



### 11. FUTURE WORK

- For future work in bicycle we can add the regenerative system which help to recharge the battery by converting mechanical work of paddling into electricity. This will reduce the time consumed as well as cost of electricity we spend on bicycle.
- To make the bicycle lighter in weight as well as of great performance and riding stability we can replace the mild steel material with aluminum alloy or better.
- We can add the digital gauges or screen on which the we can see the exact speed as well as the total distance travel by bicycle. Along with that it can also show health regarding information such as amount of calorie burn by the body as well as surrounding temperature etc.

### 12. CONCLUSIONS

After the fabrication of E-foldable bicycle, we can ride it by both electric and mechanical drive. Also, we can fold and carry the bicycle anywhere in the world. Due to its high strength and compact size it is very easy to park it inside the office, home, public places etc. Due to its efficient and green electric drive we can ride this bicycle to a great distance and it also help us to move one step toward the use of green energy.

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