" FOLDABLE ELECTIRIC VEHICLE"

A MAJOR PROJECT REPORT

Submitted in partial fulfillment of the requirements

For the award of the degree of

BACHELOR OF TECHNOLOGY

in

MECHANICAL ENGINEERING

by

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2022-2023

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CERTIFICATE

This is to certify that the project entitled "FOLDABLE ELECTRIC VEHICLE" is a bonafide work-done by **CHAPPIDI NAGANJANA REDDY(11905008), SYED MUKEETH UR RAHIMAN(11905015), VADDE MALLIKARJUNA(11905022), RAMICHETTY HARSHITH(11905030), GUMMADI SREE BALAJI (11905038), BODIREEDIGARI YAMINI(11904045), JAGGILI ANITHA(11905052,)RAMAVATH CHANDANA BAI (11905059), NAYANIVARI YAMUNA (11905066),** under my supervision and guidance, in partial fulfillment of the requirement for the award of the degree of **"Bachelor of Technology in Mechanical Engineering"** during the academic year of 2022-2023.

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DECLARATION

We declare that this dissertation entitled **"FOLDABLE ELECTRIC VEHICLE" is** a bonafide work carried out by us in partial fulfillment of requirements for the award of the degree of Bachelor of Technology in the Department of Mechanical Engineering, during the academic year 2022-2023. To the best of my knowledge, this work has not been submitted anywhere for the award of any degree.

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ABSTRACT

With growing focus on environmental issues like global warming, Electric vehicles are currently given more importance over petroleum vehicles. concentrating on old and handicapped people, this research highlights about foldable electric vehicle.

This is a light weight vehicle with mechanisms to fold into compact size according to requirement and situation which makes it easily carriable by a person and in a car's boot space. It will have a detachable battery, so that it can be easily chargeable.

By means of this vehicle, User can travel in any compact areas such as Hospitals, Parks, Work space etc. when designing this vehicle parking issues are solved and also a portable suitcase

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CHAPTER-1

INTRODUCTION

1.1 Problem Definition

Some vehicles have a problem that we need to solve. Some of the most common problems are like range anxiety, low power to weight ratio, increase in battery capacity, increase in weight, less availability of space for parking and availability of charger and charging facility. Therefore, to solve this type of problem it is simple to use it as an urban mobility, as it is easily fold able it is lightweight and easy to carry any where we want and by using the removable battery, we can carry battery anywhere to charge so exact charging point is not required.

1.2 Benefits of Foldable Electric Vehicle (FEV)

FEV's offer a convenient solution for short distance commuting, leisure activities and more. They offer a convenient alternative to driving a car or taking public transportation. They can be used to travel to work, school or errands in quick and efficient manner.

The relative advantages and disadvantages of an FEV is mainly based on cost, efficiency, pollution, safety etc.

Less Weight: Weight of this vehicle will be very low and can be carried by single person if needed. Easy to drag along the road same as trolley bag. Can be picked up and located inside the car or any other vehicle easily.

Driven any-where: Because of its small size it can be used to travel in any tight spots and also within Universities, Hospitals, Parks, Offices, Government infra, etc.

Conserves parking space: FEV's occupies less parking space when compared to a normal vehicle. As it is designed in compact size and light weight with the aim of conserving parking space and able to carry anywhere i.e., portable.

Lower Running Cost: The running cost of an FEV is much lower than an equivalent petrol or diesel vehicle. Electric vehicles use electricity to charge their batteries instead of using fossil fuels like petrol or diesel. Electric vehicles are more efficient, and that combined with the electricity cost means that charging an electric vehicle is cheaper than filling petrol or diesel for your travel requirements.

Low Maintenance cost: FEV have very low maintenance costs because they don't have as many

moving parts as an internal combustion vehicle. The servicing requirements for electric vehicles are lesser than the conventional petrol or diesel vehicles. Therefore, the yearly cost of running an electric vehicle is significantly low.

Convenience of charging at home: Imagine being at a busy fuel station during peak hours, and you are getting late to reach your workplace. These problems can easily be overcome with an electric vehicle.

No Noise Pollution: FEV have the silent functioning capability as there is no engine under the hood. No engine means no noise.

1.3 Drawbacks of FEV

- The driving range of electric vehicles is low, and you cannot cover long distances without charging the car.
- Lack of public charging stations can be an issue when driving your FEV for long distances.
- Installing a home charging module is an added expense.
- Lack of expert mechanics to service/repair eco-friendly cars.

CHAPTER-2
LITERATURE REVIEW

2.1 Overview of Fabrication of EV related papers

The literature review focuses on the findings for which the adoption of FEV could contribute to environmental conservation as well as the effectiveness to which they can operate without having a compromise on the state of the global economy.

Shlok Desai, Kavan Mehta, Zinal Kheni, Naitik Bhatt, Rahul Patel [1] From this research paper we found that after designing and modelling analysis of presented foldable electric bike we found that it will help manufacturers of foldable electrical bike to reach their goal with low cost, lighter in weight and an electric bike that can operated rough roads.

B. Sreelakshmi, C Raghvendra, MDNashad Sultan [2] Focused on the self-charge battery with the help of solar energy. It is a completely eco-friendly and helps to drive in both urban and rural area. It can easily move on concrete roads, mud roads and asphalt roads.

Jaycees S. Renge, Ronak P. Rathore, Shubham V. Bakade, Suprit P. Bardekar [3] mentioned about the design and build a coaxial, lightweight vehicle, which will consume less space for parking and can be carried along anywhere. In this project, they manufactured electric motor and tested successfully. In addition, they did their analysis by using ansys 15.0 software to measure parameters like impact effect on the vehicle to be manufactured

Deep R Prajapati, Kunjan Shinde, Abhishek Mhaske, Aniket Prabhu [4] presented piece of research paper, due to exponential increment in population and pollution consumption of natural resources of petrol,diesel is necessary to shift our way towards alternate resources like the Electric bike and others because it is necessary to identify new way of transport. E-bike is modified version of pedal cycle by using evergreen like electric energy and solar energy.

Naimeesh C H M, Naveen Kumar T, Sandeep B R, Sharath Kumar B N &Batluri Tilak Chandra [5] In this project, we knew that it is an eco-friendly foldable vehicle which emits 0% pollution. As it used foldable mechanism, anyone can carry it anywhere and can be used in places like mall, hospital, airport, etc. In addition, it can be placed in a luggage car.

CHAPTER-3

DESIGN OF FEV

3.1 3D VIEW OF FEV

By using NX CAD design and modelling of FEV was done in 1 drawing instead of part drawing. With growing focus on environmental issues like global warming, Electric vehicles are currently given more importance over petroleum vehicles. concentrating on old and handicapped people, this research highlights about fold able electric vehicle.

Electric vehicles are considered to be 97% cleaner, producing no tailpipe emissions that can place particulate matter into the air. Particulate matter, carcinogens released into the atmosphere by gas-powered vehicles can increase asthma conditions as well as irritate respiratory systems while EV does not create any such problems. This project is another step towards the development of electric vehicle scenario. This e-moped is having features like folding mechanism for solving parking problems, three wheels for better stability and compact size which helps surfing easily in crowdie areas.

This is a light weight vehicle with mechanisms to fold into compact size according to requirement and situation which makes it easily carriable by a person and in a car's boot space. It will have a detachable battery, so that it can be easily chargeable. By means of this vehicle, User can travel in any compact areas such as Hospitals, Parks, Work space etc. when designing this vehicle parking issues are solved and also a portable suitcase mechanism added which makes it simple to carry.

Fig 3.1 Design Model

3.2 DESIGNING PROCESS

Design of the vehicle begin with by measuring the dimension of the chair through NX CAD. A Design of the frame is developed with the design of the chair, like the position of chair is at center of gravity of frame. The strength of a triangle derives from its shape, which spreads forces equally between its three sides. No matter what type of triangle is used in a structure (isosceles, scalene, or equilateral), triangles are stable, as they are inherently rigid, the three sides mutually reinforcing each other. Based on the design of frame, development of suspension, position of handle, and wheels takes place. Position of electronic components made according to the design of the whole body.

3.3 CHASSIS

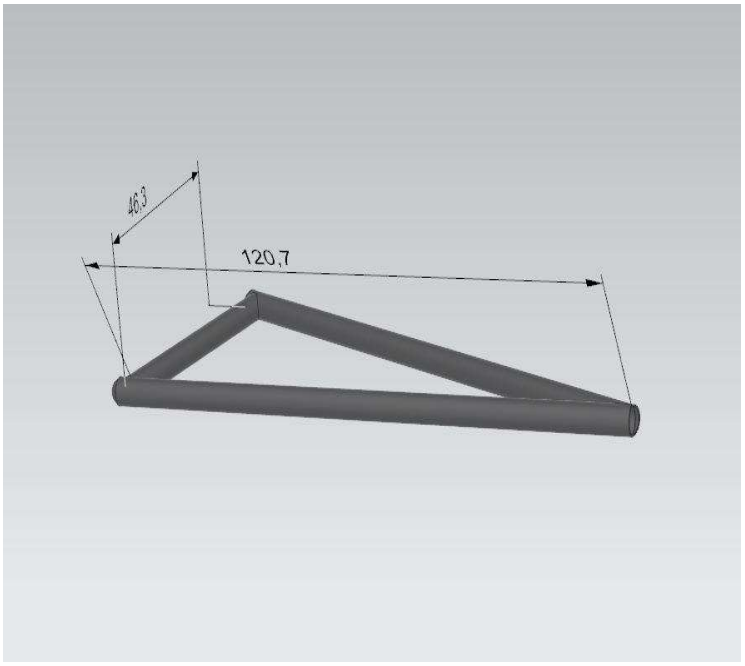


Fig 3.2 Chassis

- This part is essentially what bones are to a body, they provide a frame on which to build the rest of something.
- It transmits loads as well as components and passengers in the vehicle.
- It is made up of Mild steel.
- The strength of a triangle derives from its shape, which spreads forces equally between its three sides. No matter what type of triangle is used in a structure (isosceles, scalene, or equilateral), triangles are stable, as they are inherently rigid, the three sides mutually reinforcing each other.

3.4 SUSPENSION SYSTEM

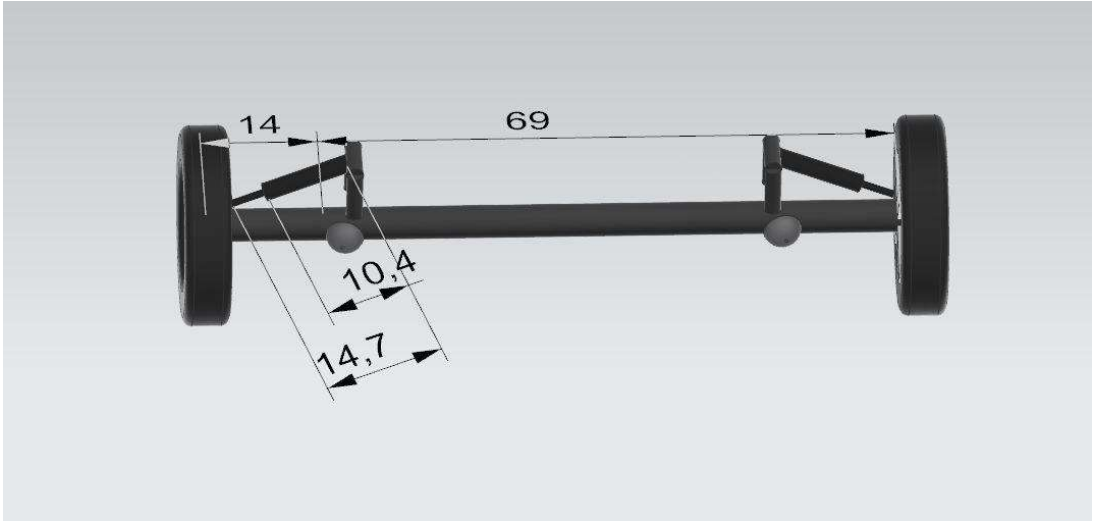


Figure 3.3: Suspension System

- Suspension is the system of springs and shock absorbers by which a vehicle is supported on its wheels.
- The function of a shock absorber is to allow the wheels to follow the curves of the road without much movement of the rest of the vehicle.

Suspension provides-

- Preload adjustments
- Compression adjustments
- Rebound dampimg

3.5 FOLDING OF FRAMES

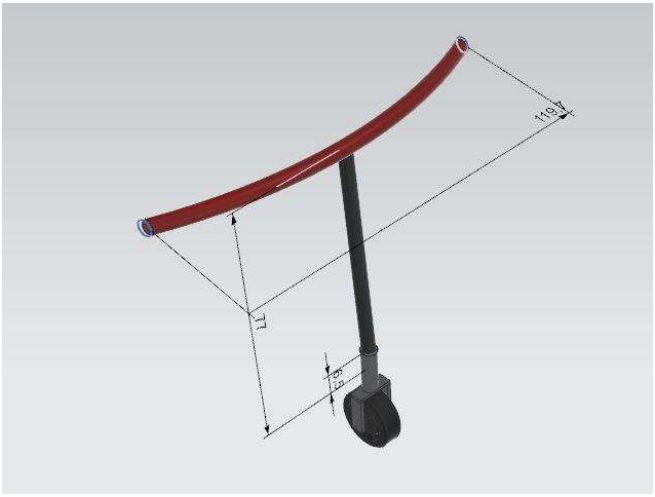


Figure 3.4: Folding of frame

- Fold able Mechanisms refer to a type of design that allows an object to be folded into a compact size for storage or transport.
- The frame's folding in this phase, the frame clamp of the folding bicycle is opened, and the folding body is folded in such a way that the front wheel's horizontal axis and the back wheel's horizontal axis are aligned.
- Handle and brakes are provided on the folding body.

3.6 ADJUSTABLE CHAIR

Figure 3.5: Adjustable Chair

- Chair is provided here instead of seat, as it is more comfortable.
- Back of the chair is fold able and the height of the chair is adjustable by up and down

CHAPTER-4
FABRICATION OF FEV

4.1 INTRODUCTION

A Fold able Electric Vehicle comprises many components such as Chassis, suspensions, Hub motor, etc., Chassis is the load bearing part of the vehicle. Chassis is rigid, strong & cost reducing. The chassis is fabricated in the shape of a triangle in a square cross-section because the triangle shape provides better rigidity, stability and strength to the vehicle. With chassis it is mounted a rod infused with nuts and bolts which is installed with a seat later on to have a function of adjustable mechanism which means that seat is moved up and down according to our requirements.

A brush-less DC electric motor (BLDC) is an electric motor powered by a direct current voltage supply and commutated electronically instead of brushes like in conventional DC motors. The Hub motor is fixed to the front wheel of the vehicle. A lithium-ion battery is attached between the back wheels. The cathode is typically a metal oxide. The battery is detachable and easy to carry with us to recharge.

The handle system is connected to the chassis by using a nut & bolt. It has three types of motions which are rotary, sliding and bending. It comprises a throttle and controller which are run by using power from the motor and handle with a steering mechanism. The handle is fold able by using a simple bending principle. The front wheel has two suspensions to get a comfortable ride and to stabilize the vehicle, back wheels have individual suspensions to shock at uneven surfaces. A charger is provided to recharge the battery.

Figure 4.1: Design Model

4.2 FABRICATION

- STEP-1 : Frame

METHOD : Metal inert gas welding
STRUCTURE : Traingular
MATERIAL : Steel

Figure 4.2.: Chassis

- **STEP-2 : FOLDABLE HANDLE**

METHOD : Metal inert gas welding
MATERIAL : Steel

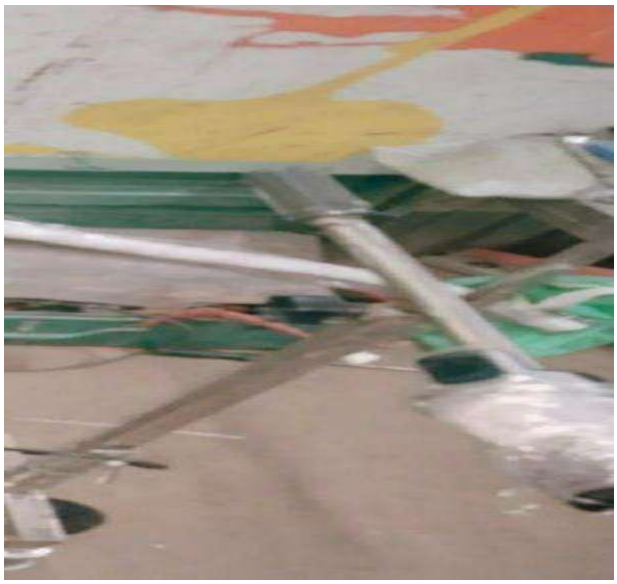


Figure 4.3: Folding Handle

- **STEP-3 : FRONT SUSPENSION**

Figure 4.4: Front suspension

➢ STEP-4 : BACK SUSPENSION

Figure 4.5: back suspension

➢ STEP-5 : SEAT HOLDING MECHANISM

Figure 4.6: Seat holding mechanism

STEP-6: SEAT FOLDING MECHANISM

Figure 4.7: Seat folding

4.3 Components Selection

Based on the FEV specifications speed, range and load capacity components of FEV are chosen. Each and every component required for an electric vehicle is either fabricated or bought from the vendors. Selecting parts, sub-assemblies for our designed output specifications of the FEV is the biggest task which can result in either success/failure of vehicle.

4.3.1 Motor

Electric motors are devices that convert electric energy into mechanical energy, usually in the form of rotational motion. Here a BLDC Hub motor is used. BLDC is an electric motor powered by a direct current voltage supply and commutated electronically instead of by brushes like in conventional DC motors.in order to obtain higher efficiency, speed and torque with less noise than brushed motor, this type is prepared.

Motor Specifications:

Rated Operating Voltage	:	24V
Rated Power	:	350W
Current	:	14.6A(maximum)
No Load Speed	:	28-30kmph
Type	:	DC Brush-less Hub Motor
Rated torque	:	30NM
Rated speed	:	25kmph
Efficiency	:	92%
Load capacity	:	more than 100kg

Fig 4.8 Hub Motor

4.3.2 Motor Controller

The controller is like the brain of a vehicle, managing all of its parameters. It controls the rate of charge using information from the battery. It also translates pressure on the accelerator pedal to adjust speed in the motor inverter.

Motor Controller Specifications:

Rated voltage	:	20-30V
Rated power	:	350Watt
Rated current	:	17A
Efficiency	:	≥92%
Under voltage protection	:	18V + 0.5V current
Current Limit	:	15A
Type	:	Pulsating (1 or 0)

Fig 4.9 Motor Controller

4.3.3 Battery

The battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices. As here Li-ion battery is considered because they are more effective and prevalent than lithium polymer batteries as they possess higher power levels making them fitting for massive usage.

Fig 4.10 Battery

Battery Specifications:

Rated Voltage	:	24V
Capacity	:	20Ah
Water Resistance	:	Splash proof
Charging time	:	5Hours
Type	:	Lithium Ion
Casing	:	Metal casing and carriable
Weight	:	3.7 - 4kg

4.3.4 Charger

Conditions of selecting the charger are it needs to be compatible with battery, for that Voltage of battery, max Capacity of battery as well as continuous charging current and discharging current according to Indian standard available input current will be 230-240 VAC, output current is based on the time of charging the battery.

Fig 4.11 Charger

Charger Specifications:

Voltage Input	:	240 VAC
Voltage output	:	24 VDC
Current Input	:	1.45A MAX
Current Output	:	5A
Charging Time	:	5hours
Type	:	Lithium ion

4.3.5 Throttle

Electric scooter throttle works by engaging the throttle while riding when you press or twist the throttle it signals the speed controller and battery to provide more power to the motor to accelerate.

Fig 4.12 Throttle

Throttle Specifications:

Voltage	:	24V/36V/48V
Power	:	350Watt
Sensor	:	49e Magnetic Sensor

4.3.6 Wheels

Fig 4.13 Wheels

Three 8-inch wheels are required. One front wheel with hub motor. Two dummy rear wheels with a weight of 400gms each.

4.3.7 Suspension

Fig 4.14 Suspension

Four suspensions of 15cm length are required. Two at front and other two at rear end.

4.3.8 Other Components

Head Light

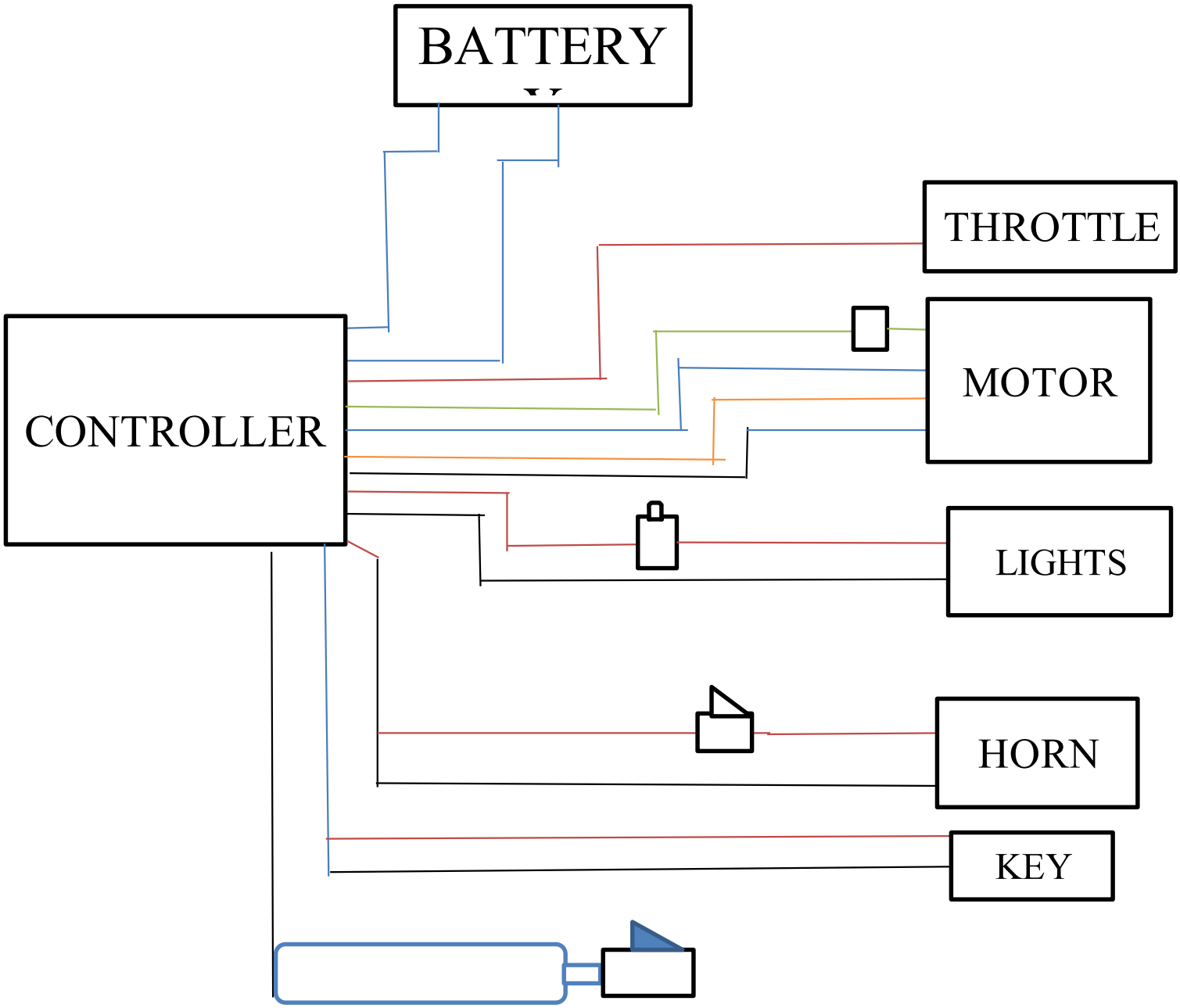
Break Levers and Break Wires

Horn

Fig 4.15 Other components

CHAPTER-5
ASSEMBLY

6.1 ELECTRONIC CONNECTIONS



Flow chart 5.1:PROGRAMMING WIRE

CHAPTER-6

CALCULATIONS

6.1 Force Analysis

Analyzing the forces acting on the frame i.e., weight of person and weight of FEV

6.1.1 Force analysis in chassis

The frame shape used for making chassis is triangular with square cross section to suit for both compressive and tensile loads and load from top transferring through "x "members support. Through this x members connected to frame from load from top (i.e., person weight) is transferred to the beam.

The maximum permissible transverse load for ¾ inch rod is "2700 lb. =1224.699 kg ". For rectangular cross section rod the resistance with standing capability will be greater than circular rod of same cross section area. But the maximum load that the frame will experience is 70 kg.

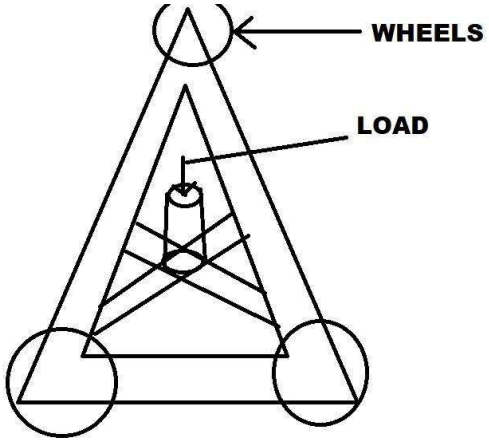


Fig 6.1 : Load analysis

The chosen triangular shape with rectangular cross section will be able to with stand repeated loads of 70kg for long time resisting fatigue failure.

6.1.2 Load on wheels

The seat is located at center of gravity of triangular frame so, the load acting on wheels will be equally divided.

Average load of person = 70 kg

Load on center of gravity = (70 + 5, 70-5) kg

Load on each wheel = 70/3 kg

= 23kg approx.

The maximum load that a wheel can be withstand is 150kg.

Wheel will be able to withstand load

6.1.3 Load on suspension

- Single shock absorbers will be able to withstand 80kg of load.
- The design included two shock absorbers on front wheel and two on back.
- The total load, the shock absorber can with stand = 80*4

  = 320 kg
- Weight of the vehicle = 14 kg
- The overall gross weight (with person) = (70 + 14)

  = 84kg

6.2 Material Selection

Name	- Stainless Steel
Phase at STP	- solid
Density	- 7850 kg/m3
Ultimate Tensile Strength	- 400-550 MPa
Yield Strength	- 250 MPa
Young's Modulus of Elasticity	- 200 GPa
Brinell Hardness	- 120 BHN
Melting Point	- 1450 °C
Thermal Conductivity	- 50 W/mK
Heat Capacity	- 510 J/g K

6.3 Speed Calculations

Fig 6.2 Hub motor with wheel

Rotatory speed of the wheel = 500-600 rpm

By considering the average speed of the wheel= 550rpm

Diameter of the wheel = 20.32 cm

Radius of the wheel = 20.32÷2

= 10.16 cm

Circumference of the Wheel = Distance covered by the wheel in one revolution

= 2πr m

= 2π× 10.16 × 10^{-2} m

For 550 rpm,

= 2π× 10.16 × 10^{-2} × 550 ×m/min

= 2π × 10.16 × 10^{-2} × 550 × 10^{-3} × km/hr

= 21.067 km/hr

If N_{min} (500rpm) is considered,

Speed = 19.1511 km/hr

If N_{max} (600rpm) is considered,

Speed = 22.9813 km/h

6.4 Range Calculations

Power of Motor = 350Watt

Voltage = 24V

Maximum Speed = 23km/hr

Maximum Load = 100kg

Maximum Current,

$$P = V \times I$$

$$I = P/V$$

$$I = 350/24$$

$$I = 14.583 \text{(at maximum speed and maximum load)}$$

Consider,

Average person weight(W) = 60 kg

Average Speed = 20 km/hr

The current(I) required by the motor for 60 kg load and 20 km/hr speed is less than 14.583(maximum current). The amount of current utilized can be tested precisely by considering friction, losses, load, accurate speed with Amp-meter.

Considering average non-fluctuating current for above case to be approximated as,

Current, I (Ideal) = 10~12(for various cases)

Range for I = 10A and Battery capacity of 25Ah

Battery can give = 10A × 2.5hr

= 25 Ah

So, for 1 hr the EV covers 20km.

Similarly for 2.5 hr the EV covers 50 km.

Considering 30% loss of current, the range obtained is 35 km.

6.5 Weight Calculations

Battery with casing	= 4 kg
Hub motor + Throttle + Controller	= 3.7 kg
Frame + Handle	= 6.3 kg
Chair	= 2 kg
Suspensions (Rear Wheel 1+1, Front Wheel 2)	= 1.2 kg
Rear Wheels (2)	= 800 gm
Break lever and wire + Horn + Headlight	= 50 gm
Total Weight obtained	**= 18.05 kg**

6.6 Charge Time

Voltage Input	:	240 VAC
Voltage output	:	24 VDC
Current Input	:	1.45A MAX
Current Output	:	5A
Charging Time	:	5hours
Type	:	Lithium ion

Charge time of 1hr is required to charge the battery for 5A

$$1 \text{ hr} \rightarrow 5A \qquad \text{Eq} -(1)$$

Calculating the charge time required to charge the battery for full capacity i.e., 25A

$$P \text{ hrs} \rightarrow 25A \qquad \text{Eq} -(2)$$

Equating (1) and (2) the charge time obtained is,

$$P = (25/5)\ (hr)$$

$$P = 5 \text{ hrs}$$

Therefore, a total charge time of 5 hrs is required to charge the battery for full capacity i.e., 25A.

6.7 Cost Calculation

Hub motor kit	= 11,000
Battery & charger	= 16,300
Chair Suspension's	= 800
Suspension	= 2,000
Steel material plots and dummies	= 800
Steel pipes	= 620
Welding material	= 1,780
Welding work	= 3,100
Total Cost	**= 36,400/-**

CONCLUSIONS

7.1 Design Conclusions

- In this research, objective of this project was to develop a lightweight, portable coaxial vehicle that required little parking space.
- Using electricity as mode of fuel, it is fully Eco-friendly vehicle.
- The vehicle consists of Lithium-ion battery, hub motor and much more features. Therefore, it is easy to fold and light in weight it so it can be carried and keep anywhere.
- Moreover, using removable battery it does not necessary to carry whole cycle to the charging point only battery should be carried away.
- Fold able E-Scooter plays a vital role in the system of Portable transportation to reach short distances. The project design is the coolest and the most efficient in present E-vehicles.
- This is the most economical and maintenance free compared to other vehicles presently being used for portable transportation.

7.2 Fabrication Conclusions

- Technical data pertinent to the project was covered in thorough literature review.
- The calculations of speed, range, weight and charge time has done and obtained to the required scale.
- The triangular shape of the chassis makes it stronger and more rigid.
- A comprehensive literature review has conducted, covering technical information relevant to the project.A formulated design approach was used to create the most efficient and robust configuration for fabrication of the fold able vehicle. The structural design was considered concurrently with component selection, aesthetics, and ergonomics to minimize mechanical, electrical and rider integration problems.
- It can be used in college campuses and industrial areas to minimize the walking distance. As it is electric motor powered, it is easy to operate. The vehicle is compact, lightweight, has simple design and hence easily portable. Cost of manufacturing is moderate. Other vehicles can be manufactured having greater capacity as well as larger area for heavy duty works.

7.3 Scope for future work

- This vehicle can be modified to provide more space by increasing suitcase size and motor capacity.
- Engine can be used to provide more power and torque if needed.
- Weight can be optimized by using more strength and light weight material.
- Thickness of chassis material can be reduced if high strength material is in use.
- If the vehicle is equipped with safety equipment's, then it can be used on public roads within certain limits.
- It can be made into four-wheel drive if size of suitcase is increasing.
- We can use electric motor hub if there is only one wheel to transmit power to vehicle.
- A differential can be used to reduce turning radius.

7.4 REFERENCES

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