Design and Manufacturing of Low Cost, Non-Polluting Urban Transport Unit

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Abstract - *Electric vehicles prove to be the most promising alternative to tackle the problem of air pollution. What we intend to achieve in this project is to provide an eco-friendly, cheap and trendy mode of transport for the masses: a vehicle that can be used by any person irrespective of sex, age, and occupation. After several iterations of chassis design considering manufacturing feasibilities and anthropometry, we came up with the most optimal design which served our purpose. FEA has been satisfactorily performed ensuring its safe design. Along with steel tubes, we have experimented with a new material in the frame - Glass Fibre Reinforced Polymer. The unique two-tube design of the vehicle gives it high strength as well as a very low dead weight. The vehicle is driven by a 48V 250W BLDC Hub Motor powered by four 7 AH, 12V sealed lead-acid batteries. The charging and discharging periods have been theoretically calculated which we have corroborated by actual experimentation. The vehicle is ideal for small distance commute in urban areas as well as for internal transport in industries and various educational institutions. Our vehicle does not require any kind of licensing or registration. We believe our project is significant with respect to offering a clean and permanent solution in the ultimate quest of finding an alternate source of energy fossil fuels in domestic transport.*

Key Words: **Eco Friendly, Economical, Electric Vehicle, Design and Analysis, Manufacturing, Testing**

1. INTRODUCTION: This document is template. By the end of 2013 January, 2,756,957[1] two wheelers were registered in Pune and this number is growing by the day. Owing to this ever increasing number of vehicles, the stores of fossil fuels are depleting at an alarming rate and the problem of air pollution has reached a potent stage. Reducing the detrimental effects of air pollution on the environment and human health was the underlying idea behind the selection of our project. Solar Powered cars, Cars that run on hydrogen fuel cells, and hybrid cars are all promising solutions to this problem. But as of now, Electric vehicles provide the easiest and most feasible solution to this problem. Electric vehicles are already available in the market, but each model has some inherent drawbacks. What we intend to achieve in this project is to provide an eco-friendly, cheap and trendy mode of transport for the masses. A vehicle that can be used all people irrespective of their age, sex or professions. A vehicle that can travel with sufficient speed that will cope with on-road traffic. A system having lesser charging time than most electric vehicles. A multi-utilitarian vehicle which can be used in a variety of applications. A vehicle that will run large distances in a single charge. And most importantly a vehicle available in the cost of a mobile phone with minimal maintenance costs and a long life.

2. Current Pollution Scenario

As stated previously, the number of petrol two wheelers has reached an alarming number. The current pollution norms enforced on two wheelers in NCR and 13 major cities in India are Bharat Stage III. The pollution emission limits are as follows:

Table 1: Emission Standards for Two Wheeler Petrol Vehicles over the years (g/km) [2]

Year	CO	HC	HC+NOx
1991	12-30	8-12	-
1996	5.50	-	3.60
2000	2	-	2.00
2005(BS II)	1.5	-	1.5
2010(BS III)	1	-	1.0

Considering an average running of 15 km per two wheeler per day,
Monthly running of a two wheeler = 15×30=450km
(Considering CO emitted by each two wheeler is 0.5gms) [3]
Quantity of CO emitted per month = 450×0.5=225gms
Quantity of HC+NO emitted per month = 450×0.5=225gms
Number of two wheelers in Pune= 2,756,957
Therefore, total quantity of CO emitted per month is 2,756,957 x 225=620315 kg

3. Cost Calculation for Existing Two-wheelers

The conventional two wheelers available in the market today are available from Rs 35,000 onwards.
Average mileage : 50 km/liter.
Price of 1 liter of Petrol : Rs. 70
Average daily running : 15 km
Monthly Running : 15×30=450 km
Running cost per month : Rs. (450÷50) × 70=Rs.630
Maintenance per year : Rs. 2000
Total Running Cost/year : 630×12+2000=Rs.9560

For a common man, an increase in these figures might make transport expensive. Reducing these costs is his primary concern. Thus, creating an option for a common man to reduce his expenses on transport and vehicle maintenance is necessary. Making this requirement as our preliminary objective, we have put forth the survey and discussion of some possible alternatives along with their respective pros and cons.

4. Possible Alternatives

Possible alternatives to the conventional vehicles are:

- Hybrid vehicles
- Solar Powered Vehicles
- Hydrogen Vehicles
- Electric Vehicles

We realized, if hydrogen powered vehicles are the greenest option available to us today purely if we only considered the pollution caused by the vehicle. This is so because; the only byproduct of a hydrogen engine is pure water. However, the processes used to synthesize hydrogen are very costly. Also, storage of hydrogen is difficult. As a result, it was concluded that hydrogen is not a viable motive fuel for the day.

Solar Powered cars will also be a very good option, considering the infinite supply of solar energy. But, the incident usable solar energy available on the Earth's surface is only about 1362W/m2. Also, the variation of this available energy with the day and night cycles and seasonal variations affects the amount of energy converted. Harnessing solar energy is a costly and difficult process and the area of the panels required to be put up on the cars make it impractical to design solar powered cars. Unless, new advanced technologies develop that would considerably reduce both the cost and area of the panels required, solar cars though promising would remain a spectator.

Electric vehicles on the other hand have much more potential in today's scenario. Firstly these vehicles are totally independent of the fossil fuels. Electric vehicles possess high drive efficiency. They produce no emissions while driving and have a very high power to weight ratio. Conversion of electrical energy to mechanical energy is easy and highly efficient. Thus the idea of developing an electric vehicle was conceived.

4.1 Objectives of Project

- Suitable for Indian Urban Road Conditions
- Multi-utilitarian design
- Easy to Manufacture and Assemble for Mass Production
- Cost effective
- Ergonomic and Trendy Design
- High Power to Weight Ratio
- Does not require a driver permit, ARAI approval or RTO registration

4.2 Design Philosophy

- Use of continuous members and One Body Concept
- Use of Glass Reinforced Polymer Tubes for construction of chassis
- Ergonomic design incorporating 95th percentile Anthropometric Studies
- Minimum transmission losses

5. Survey

We surveyed the market for different electric bikes already available. We measured the parameters like castor angle, seat height, wheelbase, ground-clearance, kerb weight, payload etc. We analysed each design and planned on incorporating all the advantages in our model. On the other hand we also analysed the inherent drawbacks of each design and planned on eliminating them. The ARAI norms specify that a driving licence and RTO registration and ARAI certification is required for two wheelers featuring a motor above 250 Watt output and a top speed under 25kmph. Vehicles under these limits are exempt from any licencing or registration. Taking advantage of this provision we decided to use a 250 watt motor and surveyed the market for the same.

We then surveyed local vehicle dealers for the front fork that would suit out requirement. We wanted a fork with a built in shock absorber. The options available to us were - TVS Scooty ES Front fork with shock absorber, Honda Activa Fork with built in shock absorber, Kinetic Velocity Electric bike, Miracle 5 Electric bike. After studying these forks, we zeroed in on the Scooty ES fork owing to its light weight and easy availability.

6. Anthropometric Considerations

After referring to anthropometric studies on design of two wheelers, we finalized certain body angles that would result into comfortable seating posture for the rider during riding. The vehicle has been designed considering 95th percentile anthropometric studies of the Indian population. [4] Emphasis has been given towards the driver comfort by use of a comfortable driving position inspired from cruise bikes.

It was important for us to choose a comfortable riding position for our bike. The Old Dutch position is the most comfortable riding posture for all age groups. [5] There are two important aspects to this sitting-position: The spine keeps in its usual double-S-shape. The whole back has the task of holding the upper body vertical, only with the help of the muscles. If you lose the double-S-shape, some muscles will be partly overstretched and can´t function properly. Every curve could make the elasticity of your spine twice as big as when there is no curve. The elasticity is necessary to protect your back against damages of bumps and it is a natural suspension for your body. The S-shape allows you to turn your upper body 180° when the pelvis is fixed. You can try it easily by yourself. If you have your back in a bad curve, you can only move your neck. It also facilitates easy ingress and egress on the bike as well as we can get easy manoeuvrability. When a rider sits on a motorcycle, the reach to the handlebars should neither be too short nor too far. The reach to the handgrips is highly dependent on the seating position of the particular bike. It is best to have handlebars that place one's hands below shoulder height, but above the knees for best comfort and control at normal speeds. The handlebar and the seating position largely determine the relative angle of one's torso while riding.

7.1 Defining Dimensional Constraints

After analysing the wheelbases and seat heights of available two wheelers we made a preliminary decision regarding dimensions. After calculating the manoeuvrability and the convenient turning radius we came to the conclusion that the wheelbase of our vehicle should not exceed 1400mm. We prepared a mock up model of the riding position to obtain feedback about the comfortable seat height, the distance of the seat from the handle and the body angles – angle at the knee and the angle at the elbow in the riding position.

Table 2: Anthropometric measurements considering comfort of the rider

Seat Height from Floorboard	570mm
Seat Height from Ground	700mm
Distance from Seat Centre to Handle	650mm
Handle Bar Width	520mm
Handle Bar Height from Ground	920mm
Ground Clearance	150mm
Angle at Elbow	150-175deg
Angle at Knee	90-110 deg
Width of Floorboard	350mm
Unrestricted Turning Angle	55 deg
Floor Board Length	450mm

7.2 Selection of Material

The main aim with a chassis is to build a stiff structure to ensure other components can work as they're designed to, and steel really scores in this respect, as it's a pretty stiff material. In addition, steel rates well in terms of both yield strength (how likely it is to bend permanently under load) and ultimate strength, particularly if it's carefully alloyed and processed. Steel also resists fatigue failure well (fatigue failure is where a material fails due to repeated loading and unloading, even though the loads involved may be far below the ultimate strength of the material). This last fact is extremely useful - even if the chassis flexes under load, such flexing need not lead to a critical failure. The only problem with steel is its weight, or more accurately its density (mass of material for a given volume). Steel is made from iron, and its density isn't far off. Although steel does corrode when exposed to adverse environments, such corrosion is not too much of a concern: A good coating, properly prepared and applied, will offer excellent protection. Only when damage is sustained which reveals bare metal does this factor became an issue. Overall, the benefits steel has as a material for chassis building far outweigh the problems of using it, and it seems that this is likely to remain the case for the foreseeable future where production vehicles are concerned. By taking into consideration all the above factors, we chose alloy steel for our vehicle frame manufacturing. As we wanted our vehicle to be cost effective, steel, which has good strength to cost ratio, was finalized as the material for the chassis. Steel has high machinability and can be welded easily; hence construction of steel chassis is comparatively easy.

We selected Alloy steel tubes of the following dimensions and mechanical properties (6)
32mm O.D., 1.2mm thick
Mechanical Properties:
Yield Tensile Strength: 400MPa
Ultimate Tensile Strength: 600MPa
Chemical Properties: Carbon- 0.19% Manganese - 2.3% Chromium – 0.56% Sulphur 0.005% Silicon – 0.55%

7.3 Motor Selection

The motor is mounted on the rear wheel hub. Brushless hub motor is selected for the application. Brushless motor offers numerous advantages over the brushed motor. For selecting the motor we have to calculate how much power is required to propel the bicycle. To find how much power is required, we have to first find resistances while riding the bike which are discussed as follows:

The gradient resistance (7) is due to the steepness of the road gradient. It depends upon the vehicle weight and the road gradient. This resistance is the maximum resistance the vehicle has to overcome. Thus, we must select a motor which is able to power the bike to climb the gradient.

We have assumed grade-ability as 8 degrees. The grade-ability value for most electric two wheelers is the same. From above figure, the resisting force due to gradient is $W\sin\theta$.

$W\sin\theta = mg\sin\theta$
$= 150\times9.81\times \sin8$
$= 204.793$ N

Other parameters are calculated as follows.

Power: Power required to propel the vehicle up a gradient of 8 degrees is proportional to the resistance to its motion and speed. Mathematically, power required (in watts) to propel a vehicle is given by

Power = R×V …….. (Neglecting transmission losses)

Where, R = Total Resistance in Newton's, V = vehicle speed in m/s= 4kmph

Required Power = Resisting Force × Velocity to climb the gradient
=204.793 × (4×1000÷3600)
= 227.547 W
From the above result we select the motor of 250W and 300rpm for our application.
Torque:
The torque given by motor is calculated as follows:
P = (2×π×N×T)÷60
T = (227.547×60)÷(2×3.14×N)
T = 7.243 N-m
Velocity on Gradient:
From the previous results for the required velocity of 25kmph, we select the motor of 250W and 300rpm. Now we have to calculate velocity with which vehicle can move on gradients and hence mathematically,
Velocity= Power/Total resistance
= 250/204.793 = 1.22 m/s = 4.39km/hr
Obtained Torque:
Maximum torque for the selected motor is calculated as follows.
P = (2×3.14×N×T)/60
T = (250×60)/ (2×3.14×300)
T = 7.96 N-m = 8 N-m
We decided to use a 250 watt BLDC Motor as our drive. The question was whether to go for a direct drive hub motor or use a chain drive. Chain drive would have required additional mountings and accessories not to mention the transmission losses. Naturally, we selected the direct drive BLDC Hub Motor for our drive. A hub motor with rim manufactured by VRLA was purchased along with its standard controller. The specs of the motor were –
i. Motor RPM – 325
ii. Power – 250 kW
iii. Torque at 325 RPM- 7.6 Nm
iv. Voltage Rating – 48V
We decided that our vehicle should have an average range of about 40kms in a single charge. Accordingly we needed to select the battery rating. We measured the real time values for current drawn by the motor under loaded as well unloaded states

Unloaded condition with gradual throttle– 0.8 Amps Unloaded condition with sudden throttle– 6.8 Amps Loaded condition with fluctuating levels of throttle– 10.6 Amps

Thus using the data we calculated the required power rating of the batteries. Battery capacity is a measure (typically in Amp-hr) of the charge stored by the battery.
It may be misinterpreted that calculating how long a battery will last at a given rate of discharge is as simple as amp-hours: for given capacity C and discharge current I time will be- **t=C/I**
However, battery capacity decreases as the rate of discharge increases. The effect is now known as Peukert's effect, the formula for calculating it is known as Peukert's equation.
$T=C_P/I^n$

where n - Peukert's exponent
Cp - Peukert's capacity
I - discharge current

The Peukert's exponent shows how well the battery holds up under high rates of discharge - most range from 1.1 to 1.3, and the closer to 1, the better. The Peukert's exponent is determined empirically, by running the battery at different discharge currents. Peukert's exponent changes as the battery ages.

The range for our vehicle was decided to be 20 km. The top speed of our vehicle was not to exceed 25kmph for it to not require any kind of ARAI licensing or registration. Thus we selected 20kmph as our top speed. Therefore the batteries should last at least 1 hour.

We tested the motor for no-load current drawn so as to calculate the discharge time of the batteries. These values are as follows

a) No-Load Gradual Throttle – 0.8 Amps
b) No- Load Sudden Throttle – 7 Amps
The rating of the selected motor was –48V 250W

Therefore as per relation –P=V x I

Therefore the average current drawn by the motor is
I = 5.208 Amps.

Thus we selected 5.208 Amps as average current - Assuming Peukert's Exponent as 1.25
Cp = T x I N
Where,
Cp = Capacity of Motor
I = Average Current Drawn
T = Number of running hours = 1
N = Peukert's Exponent = 1.25
Thus on substituting values, we get
Cp = 7.48 Ah
Thus the required battery rating was 7.48 Ah. Thus the standard 7.5 Ah lead acid batteries were selected.

8.1 Objectives of Chassis Design

The main aim was to design a chassis which would provide suitable mounting space for all the vehicle components. Also the chassis must be able to sustain all the forces acting on it and would safely transmit them to the ground. The aims adopted for the chassis were:

- Use of tubing to improve torsional rigidity and availability and ease of manufacturing.
- The chassis weight would be less than 10 kg. The use of light weight fibre glass reinforced tubes seemed to be a novel and feasible idea to achieve this goal.
- The chassis should ensure comfortable driving posture for the rider as well as adequate storage space.

- Use of continuous members in Chassis for better force transmission.
- Optimum ground clearance to be maintained as per Indian road conditions.
- Simplistic design for easy manufacturing.

8.2 Chassis Design and Analysis

After compiling all the assimilated data, we made the first CAD Model. All the dimensional constraints were successfully imposed. For static FEA, the chassis was tested for factor of safety and the deflection of the chassis under the combined weight of the rider, batteries and the self-weight of the chassis. The weight of the rider was assumed to be 100kgs and the weight of the batteries 10kgs. The weight of the chassis came out to be 4 kg considering the selected material. For safety, an overload factor of 3 was selected.
Therefore, The total load on supports – ((100 x 3) + 10 + 4) x 9.81 = 3136.79 N
The weight of the rider was applied as a uniformly distributed load on the seat beam. The axle housing joints and the collar joint was treated as rigid. Uniformly distributed load of 3000 N was applied to the seat member. Uniformly Distributed load of 100 N was applied to the battery pack holding members Material – Alloy Steel, UTS – 600 MPa, YTS –400 MPa
After several iterations considering the stability, safety and manufacturing feasibility of the chassis, we arrived at the final design shown.

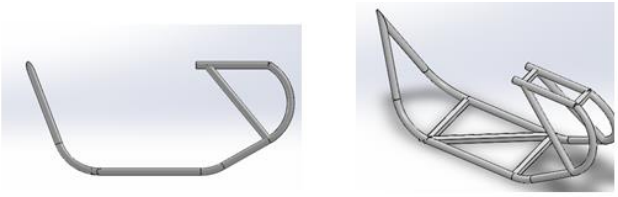

Image 1: Final CAD Model

The Maximum stress induced is – 27.16 MPa
The Maximum allowable stress for material is 400 MPa
Therefore allowable factor of safety– 14.7

Name	Type	Min	Max
Stress	TXY: Shear in Y Dir. on YZ Plane	0.00205126 MPa Element: 309	27.1621 MPa Element: 138

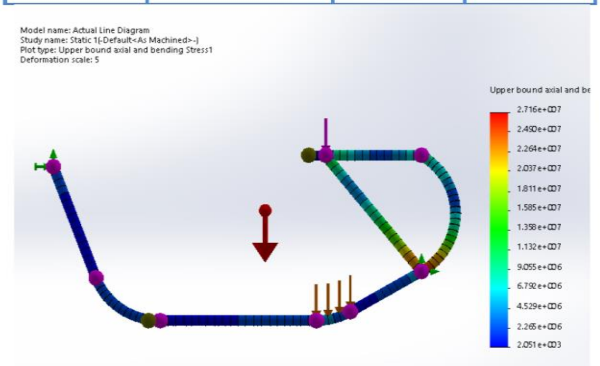

Image 2: Stress Analysis of Final CAD Model

The Maximum Displacement is 0.4mm which is allowable. Thus our design was proven to be safe with respect to stress as well as displacement.

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 76	0.407515 mm Node: 247

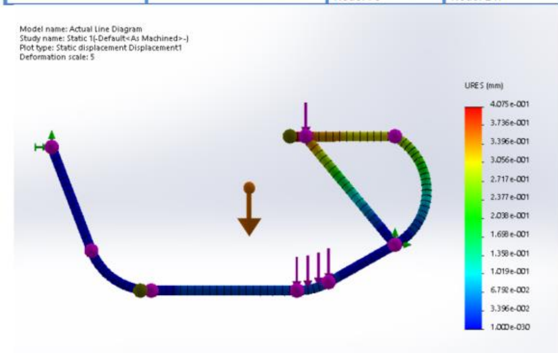

Image 3: Displacement Analysis in Final CAD Model

9. Manufacturing and Assembly

9.1 Jigs:

Jigs are clamping/positioning devices which are used in assemblies for mass-production to facilitate accurate positioning of components and speedy assembly. Jigs were prepared for the new set of wheels. Square tubes of 20mm x 20mm were used for the construction. It is essential while building a two wheeler that the wheel axels should be parallel to each other and the two wheels should be coplanar to each other. Moreover the two wheels must be perpendicular to the ground.

9.2 Fixtures:

Wooden Fixtures were prepared according to the final CAD Plots (to the scale). Plots were printed and pasted on a wooden board. Wooden blocks were nailed along the borders of the drawings. The bent pipes were placed in this constrained space to check their accuracy. This also serves another purpose, that of keeping the base frame members rigid allowing easy assembly of other components of the chassis.

9.3 Manufacturing Sequence:

MS Tube of length 6m, 32mm OD and 1.2mm thickness was purchased and bent using standard manual bending process. MS Inserts were machined in-house to specified lengths. These were used to join the fibre and the metal tubes. The chassis was erected using the jig and the symmetry about the wheels in front and top view was confirmed. The inserts were drilled so that the bolts were staggered by 90 degrees. The holes were then tapped. 6mm Butt headed Allen bolts were used for fastening the inserts. After the initial frame was erected, it was subjected to curing process to strengthen the epoxy resin applied on the snug fitting inserts. The mounting plates were welded to the members and the wheel was mounted in place. The standard Scooty ES fork was inserted in the collar and the cup-cone set was screwed and the fork was held in place. The collar was welded to the inserts in the front fibre members. The joint was further strengthened by welding gussets. The front wheel was bolted in its place using a hardened bolt as an axle and check nuts. Spacers were provided on either side of the rim to ensure the wheel does not move laterally and maintains its planarity with the rear wheel. The handlebar was welded to the protruding length of the fork by maintaining it in the designed position. In order to increase the rigidity of the chassis, cross members were welded under the floorboard. Also members were welded under the seat to which seat was screwed. The brake levers were mounted on the handle bar and properly routed to the rear and front drums. The mechanical assembly of the vehicle was thus complete. The controller was screwed under the seat to protect it from dirt and water. Connections to the motor were made. The batteries were secured in a battery box and proper connections were made. An MCB was provided for safety of the motor and controller from excess surge current. The switching circuit containing the toggle switches was mounted on a wooden switch board. The board was fastened securely under the seat. A charging circuit needed to be developed for charging the batteries on board the vehicle. The motor requires a voltage of 48 volt. To achieve this, four 12V batteries have been connected in series. To charge the batteries, however, they need to be connected in parallel and an external current of 8A needs to be supplied to the batteries. To do this, a switching circuit is developed to switch between series and parallel configurations and facilitate connection of external power supply to the battery pack. All connections from the controller through the switching circuit to the batteries, motor and the throttle mounted on the handle bar were made. The circuit was checked for continuity. Finally, the vehicle was painted using aerosol spray paint. Paneling was provided on the rear wheel arches and the front part of the vehicle. Polypropylene sheets were used for paneling.

10.1 Dynamic Testing:

The main objective of dynamic testing was to justify the design claims of range, utility, payload capacity, grade-ability and speed. The vehicle was extensively tested in major areas of the city on a variety of road and traffic conditions. In order to verify the total carrying capacity, a rider weighing 78kgs along with a kid standing on the floorboard was made to ride with no loss in top speed. The rider did not experience any jerks from the motor nor did the MCB trip (i.e. the driving current did not exceed 15A). Top speed of 27 kmph was achieved on a gently sloping road. For the project model, using 7.5 Ah batteries, a range of 15 km was achieved. Extrapolating this observation, a range of 40 km can be achieved with 17 Ah batteries. Grade-ability was tested in real life conditions. The vehicle could cross the Garware Bridge at Deccan and Veer Savarkar Flyover on Paud Road) effortlessly with a rider weighing 94kg.

10.2 Testing and Feedback

In this stage of testing, the various parameters of the actual vehicle were compared with design parameters of the vehicle. This was done to ensure manufacturing accuracy.

Parameter	% Deflection from Designed Value
Wheelbase	-3%
Ground Clearance	+20%
Seat Height	-2.77%
Floorboard width	-9.09%
Handle Height	-2.73%

10.3 Battery Runtime Evaluation:

Battery Rating is 7.5Ah. The charging current recommended is 10% of the capacity rating. Taking into account the losses in transmission and efficiency of charging, the charging current was set as 2.5 Amps. We procured a battery charger delivering 10 Amps current at 18V. We connected this charger to the batteries connected in parallel. Thus, the current drawn by 1 battery was 2.5 Amps. The charging time was = 3 hrs.

As Mentioned earlier, we calculated the average current drawn as 5.208 Amps. We calculated the full load current drawn by the motor by actual calculation. For our 7.5 Ah battery pack and our vehicle top speed of 25 kmph we could get the total range as 15kms. Therefore, the total battery runtime = Speed / Range is T = 0.6 hrs = 36 mins. Therefore, the average current drawn by the motor when the vehicle is fully loaded is –Total capacity/Average runtime = 7.5/0.6 = 12.5 Amps.

10.4 Key Features and USPs of the Vehicle

Image 4: Finished Vehicle

- Non Polluting and has a very low running cost (23 paise per km)
- Use of Fiber Glass tubes in Chassis Construction
- Simple and Trendy design which is easy to manufacture and appealing to the eye.

- Lightweight Construction
- Highly Maneuverable
- Easy to drive as it has standard controls
- Suitable for all age groups
- Ideal for internal transport in industries and large educational institute campuses
- Ideal for short distance commute
- Can be used by delivery personnel

10.5 User Feedback Analysis

The objective of this project is to develop this vehicle as a commercial product which will overcome the drawbacks of conventional and electric two wheelers and give customers an economical and an appealing option. Thus, the response of customers towards this vehicle was of critical importance. So, we took trial runs of the bike from people and noted down their feedbacks. Following is the questionnaire we distributed to people. The responses were plotted in the form of graph.

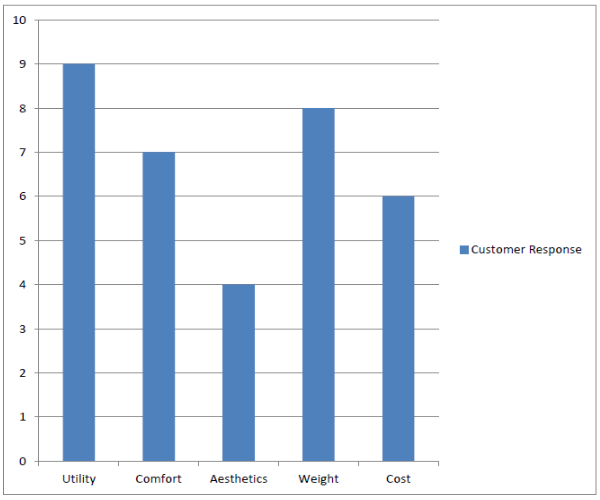

Chart 1: User Feedback Graph

Most people found the vehicle fit for daily commute as well as luggage carrying. Many of them claimed that the vehicle is good for carrying small goods like grocery, vegetables, etc. Also, some claimed that the vehicle is perfect for even carrying a child with them. Few pointed out that the vehicle can carry only one adult person and it should have carried two. People were having mixed feelings about the rider comfort still they found the riding posture, seat and handle height comfortable. The vehicle wasn't much appreciated from an aesthetic point of view. People found it different, not attractive. The response over chassis design and shape was fair. People were satisfied about the weight of the vehicle. The less weight makes riding easy for senior citizens and appeals the rest too. They had mixed responses about the cost of the vehicle. According to some, the vehicle buying cost was high with respect to its aesthetic. But many were happy about the less running cost due to very low electricity consumption.

10.6 Expansion Plan and Future Scope

- Use of glass fiber reinforced polymer members for complete chassis construction
- Preparing fixtures and tooling for mass production
- Vehicle security, electronics and aesthetics
- Aesthetic improvements

11. Conclusion

Having realised that electric vehicles provide the most promising solution to the problem of pollution, we successfully designed, developed and manufactured an electric bike that would provide an alternative to the conventional two-wheelers running on the roads today. The cost of our vehicle is about Rs 26000 which is less than any other two-wheelers available in the market. The calculated running cost of our vehicle comes out to be 25 paise/km. We were able to design a product which can be used for a variety of purposes and which can be conveniently driven by all people irrespective of their age, sex or occupation. We were able to develop and manufacture a fully working prototype with considerable accuracy towards the design.

12. Acknowledgements

We would like to thank the college and our guide Prof. H.N.Deshpande for allowing us to pursue with this project and for providing us support and guidance throughout the tenure of the project. We would like to thank our sponsor Mr. Shrirang Chandekar of LeanWay Energy Pvt. Ltd for providing us an opportunity to work on this project. We would also like to thank Diamond Craft Industries and Autotronix Engineers for sponsoring us with material and facilities needed in order for manufacturing of the vehicle. We would like to thank specially the workshop staff for allowing us to use the college workshop premises and facilities during our project and Prof S.M. Ramnani for his support and guidance.

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