Design and Development of Electric Vehicle for Garbage Collection

Akshay Shilimkar[1] Mayur Shilimkar[2]
[1]ZCOER Pune University, India [2]RMD sinhgad Pune University, India

Abstract— Increasing long-term gasoline price and worries on the impact of emissions have encouraged alternative technologies like electric vehicles (EVs). As a part of the initiative to increase local air quality, cities encourage the adoption of EVs in mass transit system. Electrification is the most feasible way to achieve clean and efficient transportation that is crucial to the sustainable development of the entire world. In the near future, electric vehicles (EVs) including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and pure battery electric vehicles (BEVs) will dominate the clean vehicle market .By 2020, it is expected that more than half of new vehicle sales will likely be EV models. For our study of the core aspects of electro mobility, we have chosen the areas of environment, politics, economy, society, infrastructure and technology. It is not possible to completely separate the content of these areas because there are complex Relations between them. Climate change and the conditions for the use of fossil resources (limited availability, price) are causing countries to change their climate and energy policies and are causing changes to their national societies. Politicians are answering to these changes with national emissions limits that unfortunately vary at international level. As a rule, these limits cover direct emissions of CO2 or other environmentally harmful gases. Electric vehicles do not produce direct emissions in the form of CO2.

Key words: Design, Analysis, Electric Vehicle

I. INTRODUCTION

There is growing demand for fossil fuel like diesel and petrol to power the automotive and fulfil other needs of human. Fossil fuels are being depleted because of their extreme use and limited stocks. Further the use of fossil fuels is polluting the environment. In metro cities level of pollution from vehicles, during peak hour is dangerous. Because of this people are forced to wear mask for filtering the polluted air for respiration. Further, there are frequent traffic jams on the road due to this there is waste of fuel and time. All these factors are responsible for various problems in human such as headache, stress, reduced performance etc.

To minimize all these problems and to keep our earth free from pollution and human health and fitness, there is an urgent need to explore alternative in place of fossil fuel powered vehicles. Efforts are being put to develop vehicle powered by solar energy, hydrogen, biodiesel and batteries. Battery powered vehicle are not so popular in India because they need frequent charging, small distance travelled in single charging, small range of speed in comparison to conventional automotive short battery life etc. In order to overcome above mentioned problems an attempt has been made to design and fabricate environment friendly, battery powered, Electric Vehicle.

An electric vehicle, also called an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or a generator to convert fuel to electricity. EVs include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft.

Unlike vehicles with combustion engines, electric vehicles do not produce exhaust gases during action. This alone makes electric vehicles more environmentally friendly than vehicles with conventional technology. However, the electrical energy for charging the vehicle does have to be produced from renewable sources, e.g. from wind, solar, hydroelectric or biogas power plants.

A. Methodology:

The idea is to Design and development of electric vehicle which can be used in rural areas. At the same time taking in concern the cost of manufacturing. The initiation with design calculation » cad modelling» iterations »market survey » material selection » manufacturing of components(chassis, breaking, suspension, steering system, etc.) » assembly » testing » results.

B. Overall Vehicle Details:

Parameters	Specification
Battery	LiFePO4
Power	1500 kw
Torque	44 Nm
Curb weight	200 Kg
Pay load	400kg
GVW 600kg	600kg
Wheel base	2300 mm
Track width	710 mm
Maximum speed	28 km/hr
Turning radius	3 m
Acceleration 0-25 km/hr	13 sec
Battery capacity	4.8 kW/hr
Range per charge	64 km

Table 1:

II. POWER REQUIREMENT

Following are the required values for power calculation
1) Gross vehicle weight (GVW) = 1000Kg = 9810N
2) Weight on each drive wheel = 333.33Kg =3270 N
3) Radius of wheel or tire = 14 inches = 35.56 cm= 0.3556 m
4) Desired acceleration time (ta) = 20 Sec
5) Desired top speed (Vmax) = 25 kmph = 6.95 m/s

Total tractive effort is given by

$$TTE= RR+FA+ Fd$$

– NOTE: Considering vehicle running on flat road.
– RR = Force necessary to overcome rolling resistance
– FA = Force required to accelerate to final velocity

But, Fd = Force required to Drag
The total tractive effort is 271.21 N.

To verify the vehicle will perform as designed in regards to tractive effort and acceleration, it is necessary to

All rights reserved by www.ijsrd.com

calculate the required wheel torque (Tw) based on the tractive effort.

Wheel motor torque (T_w) = TTE x R_w x R_f

Resistance factor is assumed as 1.

Therefore the wheel motor torque comes out to be 48.221 N-m.

Power (P) required to drive a vehicle at the speed (v) can be calculated from the formula,

$$P = \frac{2\pi N T}{60}$$

For power we have calculated motor RPM using above formula, Therefore,

$$V = R_w \times N \times 0.10472$$

$$N = 400 \text{ rpm}$$

By using the above values in the power equation. We get power as P=1884.89 Watt which is 2.52 hp.

III. Battery

EV batteries are quite different from those used in consumer electronic devices such as laptops and cell phones. They are required to handle high power (up to a hundred kW) and high energy capacity (up to tens of kWh) within a limited space and weight and at an affordable price. Extensive research efforts and investments have been given to the advanced battery technologies that are suitable for EVs all over the world.

Rated Wh Capacity = Rated Ah Capacity x Rated Battery Voltage

A. *Selection of Battery:*

We have selected Battery Having Following Specification

1) Rated Wh Capacity=4800 Whr
2) Rated Ah Capacity=100 Ah
3) Rated Battery Voltage= 12 V*4

Range calculation for electric vehicle

Power required by vehicle for 1 hr = 1500 Whr

Rated Wh Capacity=4800 Whr

To Extend Battery Life we do not Discharge batteries more than 80 %

Usable Pack size: Wh x 0.80 x peukerts = Usable Wh

= 4800 x 0.80 x 1.0

Usable Pack size = 3840 Wh

Peukerts:

LiFePO4 = 1.0

Lead- Acid =0.55

We are using LiFePO4 battery's in Electric Vehicle.

Running Time (hr) = Rated Wh Capacity / Power Required by vehicle

= 3840 /1500

Running Time (hr) = 2.56 hr

Range of vehicle = Running Time (hr) x velocity of vehicle (Km/hr)

= 2.56 x 25

Range of vehicle = 64 km

– Conclusion

We have selected Four Lithium ion batteries of usable pack size (12 V, 100 Ah).

B. *Controller*

A motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

1) Specification

1) Voltage-48V
2) Maximum current -50Amp
3) Motor type-brushless Motor
4) Motor power -1000 watt
5) Casing-Aluminium

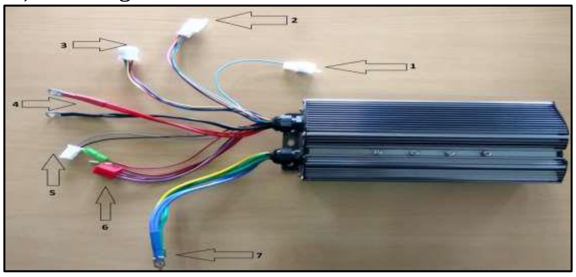

Fig. 1:

2) Features

1) Low noise
2) Neutral function
3) Forward-Reverse function
4) Strong climbing
5) Battery Status feedback

– Conclusion

We have selected 48 V Controller according Motor and Battery

– Specifications.

IV. Analysis of Chassis

A. *Static Analysis of Chassis*

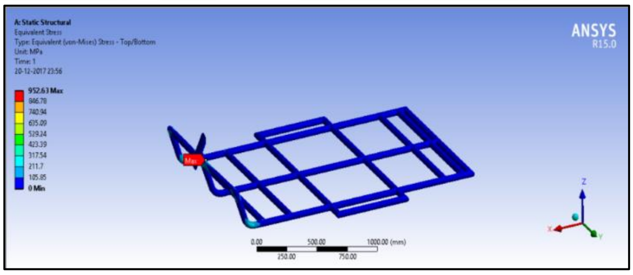

Fig. 2: Static Analysis of Circular Cross Section

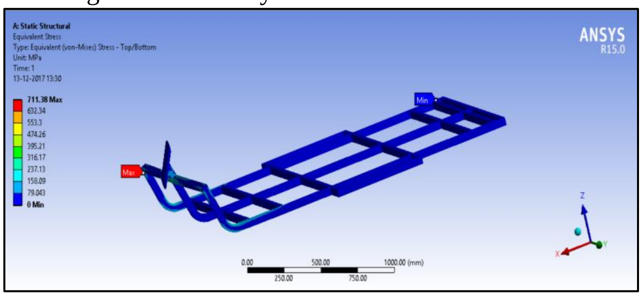

Fig. 3: Static Analysis of Rectangular Cross Section Iteration 1

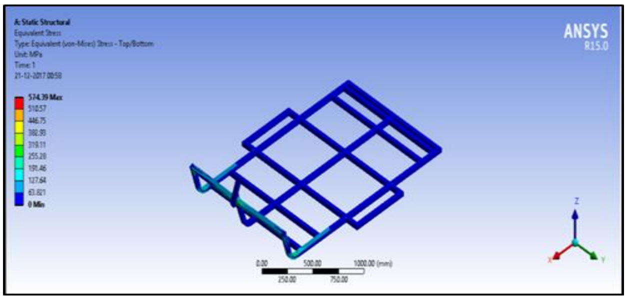

Fig. 4: Static Analysis of Square Cross Section Iteration 1

B. *Results*

Parameters	Circular Cross section	Rectangular Cross section	Square Cross section
Cross section (mm)	50	45x25	40x40
Weight (kg)	34.085	34.02	37.922
Stress (Mpa)	952.63	711.38	574.39

Table 2:

Therefore, from above Results we have selected square cross section.

C. *Analysis of Square Cross Section Chassis*

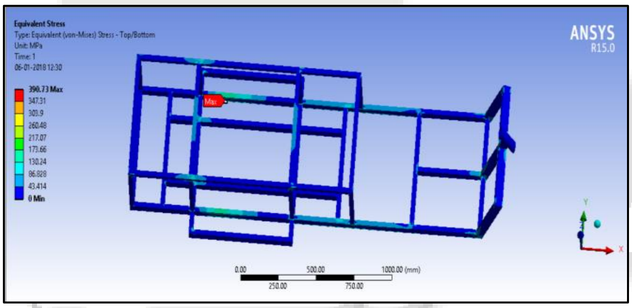

Fig. 5: Static Analysis of chassis Iteration 2

1) *Cad Model*

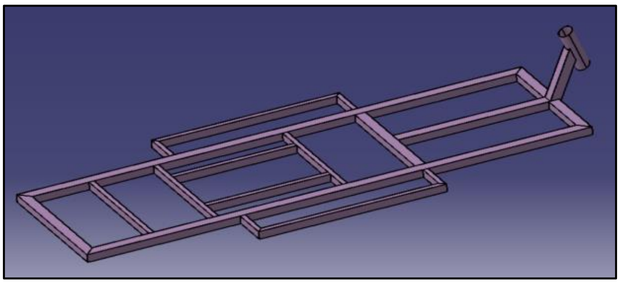

Fig. 6: CAD Model of Chassis

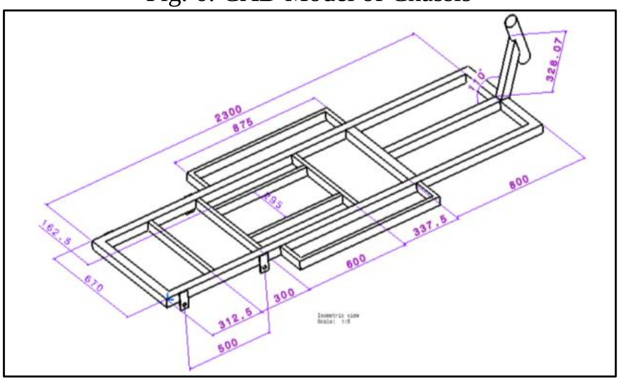

Fig. 7: Dimensions of CAD Model of Chassis

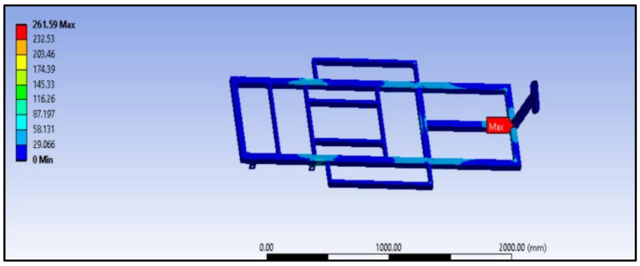

Fig. 8: Static Analysis of chassis Iteration 3

Iterations	1	2	3
Cross section (mm)	40x40	50x50	50x50
Stress (Mpa)	574.39	390.73	261.59

Table 3:

Therefore, the stresses in iteration 3 are less than yield strength of material so chassis is safe Front Impact of chassis:

From Conservation of momentum: $m1v1 + m2\,v2 = (m1 + m2)v_f$

- m1 = mass of vehicle
- v1 = velocity of vehicle
- m2 = mass of another vehicle
- v2 = Velocity of Another vehicle
- v_f = Final velocity of vehicle
- $300x6.94+ 500x\ 0 = (300 + 500)v_f$
- $v_f = 2.6025$ m/s
- From Rectilinear Equation:
- $v_f = u + at$
- u = Initial Velocity
- a = acceleration
- t = time (sec)
- 2.6025 = 0 + a x 0.1
- $a=26.025 m/sec^2$

From newton's 2nd law

- F = m x a

The calculated force is F = 7807.5 N

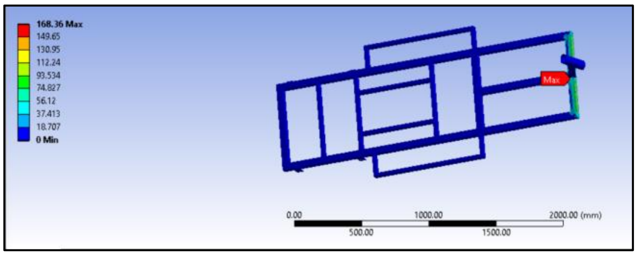

Fig. 9: Front Impact Analysis of chassis Iteration 3

Therefore, the stresses in iteration 3 are less than yield strength of material so chassis is safe.

V. DESIGN OF LEAF SPRING

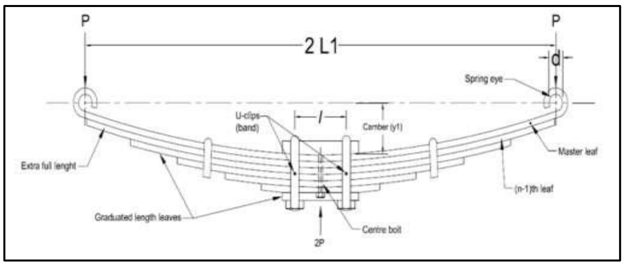

Fig. 10: Leaf Spring

All rights reserved by www.ijsrd.com

The basic requirements of a leaf spring steel is that the chosen grade of steel must have sufficient harden ability for the size involved to ensure a fill martensitic structure throughout the entire leaf section. In general terms higher alloy content is mandatory to ensure adequate harden ability when the thick leaf sections are used. The material used for experimental work is 5Si2Mn90.

A. *Design Input*

1) Weight of vehicle = 230 kg
2) Weight of Driver =70 kg
3) Maximum load carrying capacity =700 kg
4) Material of springs =65Si7
5) Youngs modulus (E) =2.1*10E5 Mpa
6) Poisons Ratio =0.266
7) Ultimate tensile strength(σut) =1272 Mpa
8) Yield tensile strength (σyt) =1158 Mpa
9) FOS =1.5
10) Width of spring (b) =50 mm
11) Thickness of spring (t) =6 mm

Various design values for leaf spring are as follows:

Total load on wheel	9810 N
Force on each leaf spring (F)	4905 N
Effective length of spring (2L)	490 mm
Allowable Bending Stress	386 Mpa
No of leaf spring (n)	~ 5
Deflection	16 mm

Table 4:

VI. BRAKE SYSTEM

The maximum brake force that can be generated on application of drum brakes are a compound of the force applied on the lever, the mechanical advantage offered by the connecting linkages and a function of the shoe efficiency

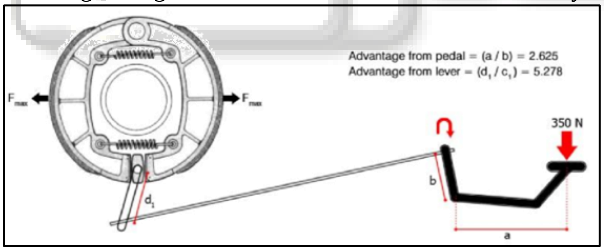

Fig. 11: Rear Drum Braking System

The rear braking system for standard drum brakes consist of a pedal, rod and lever at the drum. To calculate the brake force at the brake shoe we have to consider the force at the pedal and the force multipliers such as the linkages. The mechanical advantage provided by each linkage is calculated independently and then compounded to obtain the total brake force at the shoe.

A. *Result*

Maximum brake force for a rear drum brake = 240 kgf
Maximum brake torque for a rear drum brake = 40 kgf-m

B. *Cost Estimation*

Work Description	Allotted maximum cost (INR)
Battery	32000
Controller	1800
Motor	5000
Differential	5000
Wheels	900
Chassis Material	3500
Leaf spring	700
Steering Assembly	2500
Cabin	5500
Throttle	350
Adjustable Rod	300
Indicator	250
Total Cost	57800

Table 5:

VII. CONCLUSION

Our goal was to design and manufacture a complete electric vehicle that would carry municipal waste in the city. Also other major goal was to make the vehicle cost effective so that I can be mass produced and used in various parts of the country for carrying waste. We have also planned the various other designs of the vehicle where the same vehicle with some modification could be used for various other purposes such as public transportation.

Looking at the environmental conditions, we made a non-polluting vehicle, which will completely work on stored electric energy. We hope to keep down the pollution by making use of such vehicles in the future. This effort will certainly decrease the use of fossil fuel and increase the quality of air.

REFERENCES

[1] Sharad Patel et al “Design and Development of Three Wheeled Campus Vehicle”, International Journal of Scientific & Technology Research, Volume 5, Issue 08, pp :(19-114), 2016.
[2] Ashish Kumar Singhal et al “Solar Electric Powered Hybrid Vehicle”, Journal of Electronic Design Technology, Volume 6, Issue 3, pp :(1-9), 2015.
[3] Sharada Prasad N et al “Design and Development of Hybrid Electric Twowheeler Suitable For Indian Road Conditions”, International Journal Of Electrical, Electronics And Data Communication, Volume-2, Issue-9, pp:(59-62), 2014.
[4] S.M.H.S. Omar et al “Design and Optimization of Powertrain System For Prototype Fuel Cell Electric Vehicle”, Journal of Mechanical Engineering And Sciences (Jmes), Volume 8, , pp:(1401-1413), 2014 .
[5] Santosh Ukamnal, “Design of Trailing Arm Suspension”, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 6,pp:(87-91), June2014
[6] Amit Phatak et al” Review on study and analysis of Drum Brake to control Squeal Noise”, International Engineering Research Journal,pp:(1-8) 2014.
[7] Phadnis Swapnil and Chavan Bhushan,” Microstructure and Roughness Analysis of Drum Brakes of Maruti 800”, International Journal of Science and Research (IJSR) ISSN,pp:(3035-3037) 2013.
[8] Meenakshi Kushal et al,” Optimization of Design of Brake Drum of Two Wheeler through Approach of Reverse Engineering by Using Ansys Software”, Journal

All rights reserved by *www.ijsrd.com*

of Mechanical and Civil Engineering (IOSR-JMCE), pp(11-17)2015.

[9] Mohammed Noorul Hussain et al "Design, Analysis and Fabrication of 3-Wheeled Hybrid Vehicle Run by Human Effort and Electric Motor."Savitribai Phule Pune University RMDSSOE, BE (Mechanical Engineering) 69 International Journal of Engineering Research & Technology (IJERT) ,Vol. 3 Issue1, pp:(1396-1401) , 2014.

[10] M. Anudeep and Snehalatha. P., "Dynamic Response Analysis of a Three Wheeler Chassis Frame using Finite Element Analysis." International Journal of Scientific Engineering and Technology Research" Vol.04, Issue.57,pp: (68-73),2015.

[11] Rahul Shinde, Sneha Patale, Aniket Pawar, Vidhya Shinde, and Prof. Balaji Chaure,"Analysis and Fabrication of Rollcage for Solar Vehicle." International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME) Vol. 3, Issue 1, pp: (56-63), 2016.