Design of Chassis & Comparison of Material & Energy Efficiency of Hybrid E-Rickshaw

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Abstract— India the 2nd most populous country is getting infested with pollution. This problem is largely attributed to the emissions caused by fossil fuel driven vehicles. With its rising population and growth in the urban sector, the increasing demand for sufficient transportation has led to make advancement in the field of public transportation using clean energy resources. Amidst the various types of terrestrial public transportation, there is a highly popular mode of transport called the Auto-Rickshaw. These vehicles are three-wheelers that perform the same duties as a taxi in terms of transporting people and goods from point to point. However, they are different because of their small size and ability to weave through traffic .This project provides an alternative solution that will achieve substantial reduction in energy consumption as well as the use of Hybrid Solar commercial vehicles under a manufacturing industry DMW Electrical vehicle Om Balaji Pvt. Ltd. This research paper basically deals with Design Of Chassis And Comparison Of Material under various test And Energy efficiency Of Hybrid E-Rickshaw of category L-5 (Maximum speed of 50km/h) for better safety High loading capacity and better Ergonomics in this new vehicle making current transportation run on clean fuel.. The CAD model of a three wheeled vehicle is developed using the commercial software Solidworks. Our main objective in presenting this research paper is on the chassis design of e-rickshaw and optimization for better factor of safety at increased speed and ways to introduce solar panel in the frame work design and to improve and upgrade e-Rickshaw, which are currently in use, with solar PVs in semi-urban areas of India.

Key words: Chassis, E-Rickshaw, Materials, Solar Panel, Auto Rickshaw, Three Wheeler, Solidworks

I. INTRODUCTION

The word "Rickshaw" originates from the Japanese word "jinrikisha". In Japanese language "Jin" means human, "Riki" mains power or force and "sha" means vehicle. So, literally "jinrikisha" means human powered vehicle. In India we use power driven commercial three-wheeled road vehicle on large scale and are important part of transportation system in major cities and being most popular in smaller towns. This vehicle, commonly known as an Auto-rickshaw. The next two decades are likely to witness a sharp rise in the use of three wheelers. Auto rickshaws are typically petrol driven, though the government is currently supporting the production and use of CNG (Compressed Natural Gas) driven rickshaws. Even though CNG rickshaws resolve the pollution issue, India still has to import most of the CNG that is used in the country. Three wheelers also have the advantage of being a compromise between two wheeled and four wheeled vehicles in various aspects like cost, load carrying capacity, fuel consumption, space occupied, weight etc. The three-wheeled vehicles operating in India have their front steering with one wheel similar to those of motor cycles and motor scooters, the two rear wheels are the driving wheels with a differential and a suspension, which are similar to those of automobiles. All These reasons compel use to find a more effective design and fuel for commercial auto rickshaw. The concept is simple, an electric three-wheeler that is powered by a battery source which in turn is recharged by a solar panel or electric outlet. Our economic evaluation shows that the daily cost of operating/owning the suggested hybrid rickshaw when properly subsidized is cheaper than the petrol fuelled rickshaw, therefore our goal is to completely replace the petrol-powered three wheelers.

II. TECHNOLOGY & DESIGN METHODOLOGY

This hybrid model of auto rickshaw will be using a series hybrid system which will be used for storing energy in a battery. The normal electric rickshaw used to have a problem i.e. once battery is discharged then first it is necessary to charge the batteries with electricity to run vehicle. In India there is lack of electricity. These problems are solved with an alternative solution i.e. series hybrid system. Series hybrid system uses two power sources i.e. solar and electricity. Solar energy is trapped by the solar panel and converted to electric energy and another through charged batteries and alternator. Hybrid vehicle has many advantages in the current world where pollution is a big problem. The vehicle runs by means of Brush Less DC motor ranging from 650- 1400 Watts which get their required power by means of the battery. It consists of the controller unit. The battery used is mostly Lead acid/Li-ion battery or Deep discharge/cycle batteries designed for EVs.

The choice of material for a vehicle is the first and most important factor for automotive design specially its chassis and body frame. After the material selection the next step is deciding the type of Chassis to be used in vehicle, various loading conditions under which analysis will be done, along with the solar panel, battery and motor selection criteria keeping in view of the Economic analysis of vehicle. All this information is too collected and compared with the present specification of manufacturing industry to get optimized results. After that basic idea of design is prepared based on that CAD model of hybrid rickshaw is prepared using Solid works. Various calculations and comparisitions are done with present vehicle in the market. Static Analysis of chassis is done on Ansys and Solidworks to get various result.

A. Specification

Whenever the designing of any system is considered the main thing that needs to be noticed will be the specification. In this project, panel specification need to be given for that the knowledge of surface area of the auto, power need to be produced by the panel and cost etc. plays a major role thus the following is referred

1) Battery Specification

The batteries mainly store the excess power from the solar panels to give backup for night hour's use. They also supply the initial torque to start the motor. The batteries are 6 x 12 Volts, 120Ah.

2) Motor Specification

At 12 Volts the motor can run at 1250W.

3) Solar Cell Specification

2000 W, 3 x 24volts solar panel.

4) Solar Controller

The Solar controller is like a fuse which regulates the current from the panels to the motor.

B. Material Selection

There is a variety of materials that can be used in the vehicle body and chassis, but the purpose of design is the main challenge here. The most important criteria for material selection is that a material should meet are lightweight, economic, effective, safe and durable life cycle. The chassis consists of the internal and external frame work which is used to support the vehicle under the different circumstances they face during the working of the vehicle. We will be comparing and optimizing results using material ERW and CEW Grade D steeland AISI1018.

	% C	% Mn	% S	% P	% Si	UTS (MPa)	YS (MPa)	%EL
ERW C1	0.15	0.6	0.06	0.06	0.15	300	200	10.0
CEW C3	0.25	1.2	.05	0.05	0.35	480.1	400.1	--
AISI 1018	.20	0.9	0.05	0.04	0.4	480.1	349.9	15.0

Table 1:

C. Design of Chassis Frame Work

The initial idea was presented before company out of which the prescribed to work on the idea as it was Most basic and familiar design for Indian market It has Improved chassis for increased safety and stability with Provision of replaceable solar panel on roof which can also be used for carrying luggage

They also suggested us that Instead of FRP to use optimum thickness sheet metal as it can be repaired more easily Based on their recommendation the first CAD model of chassis is prepared using Solidworks .The team also determined the approximate weights of various components and based on those weights reactions on the chassis beam was calculated to find out bending moment and finally stress using 1.9 inch OD pipe for long bar and 1.3 inch OD pipe as cross bar. The further analysis will be done on Solidworks simulation and Ansys.

After material selection the CAD model of auto rickshaw was prepared using Solidworks having following dimensions and various loads which will be contributing to overall weight of vehicle

NO	Component	Weight (kg)	Position from origin(mm)
1	Driver	70	800
2	Battery	20*6=120	1000-2600
3	Passenger 1&2	140	1200
4	Passenger 3&4	140	2400
5	Seat for driver	5	800
6	Seat for P 1&2	12	1200
7	Seat for P 2&3	12	2400
8	Chassis body	128	1758
9	miscellaneous	80	
	TOTAL	707	

DISTRIBUTION OF WEIGHTS OVER CHASSIS

no	Description	Dimension(mm)
1	Overall length of chassis	2600
2	Overall width	1250
3	Overall height	1800
4	Ground clearance	300

SPECIFICATION OF CHASSIS

Fig. 1:

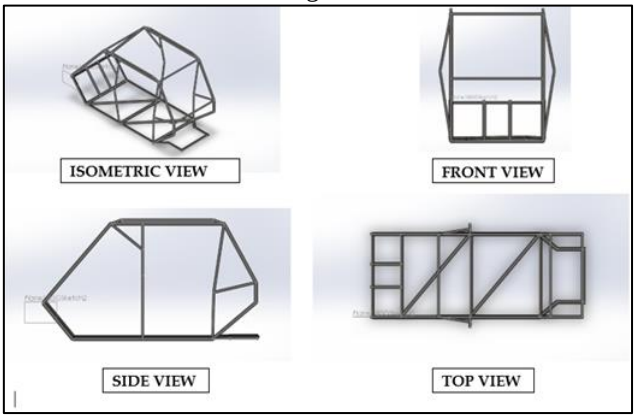

Fig. 2: Modelling In SolidWorks

III. MATHEMATICAL MODELLING

Force analysis of hybrid rickshaw up the inclined plane

$$P=F*V$$

Assuming velocity V=42 kmph

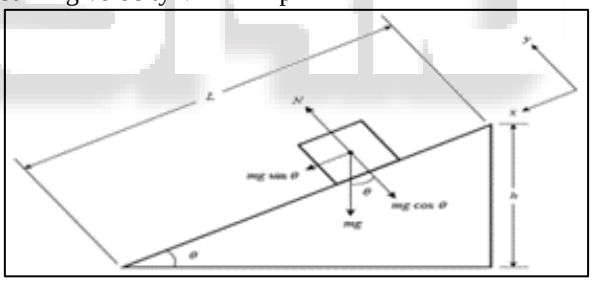

Fig. 3:

	MASS (kg)	INCLINATION (degree)=0	INCLINATION (degree)=4
POWER REQUIRED	707	16.16KW	21.79KW

Table 2:

For the selected solar power cell

Power output per unit area= 168 W/m^2

For our CAD model we have achieved 1.7 square meter

Total extra power through solar cell = 168*1.7 = 285.7W

IV. SIMULATION

The vehicle frame has been analysed for static structural bending ,front impact test and rear impact test Some other tests also like torsion test, side roll over test and bump tests are also there but the maximum load occurring in these tests is much lower than the above mentioned tests. Hence they automatically satisfy the criteria of higher factor of safety. After Analysis, minimum factor of safety was found to be 1

in rear impact test. In other tests, the factor of safety was more than this value for CEW and AISI. This is acceptable.

A. Static Structural Test

The static structural test simulates the vehicle in a static condition under full load.the total weight of vehicle is 707 kg.It is taken at the centre of gravity and reactions are calculated for each wheel joints

B. Front Impact Test

The front impact test simulates the vehicle hitting a solid, immovable object at a maximum speed of 45Km/hr. The impulse time is taken as 0.1 sec. According to Newton s second law of motion, the force acting on vehicle is 3mg.

C. Rear Impact Test

The rear impact test simulates the vehicle being hit by another vehicle from rear side, at a speed of 45 km/hr. The impulse time is taken as 0.1 sec. According to Newton's second law of motion, the force acting on vehicle is 2.5mg.

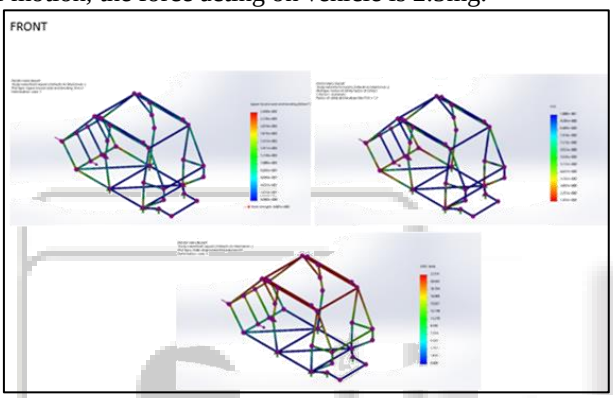

Fig. 4:

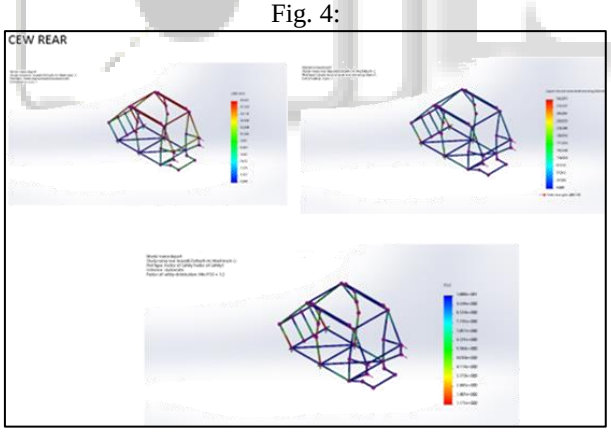

Fig. 5:

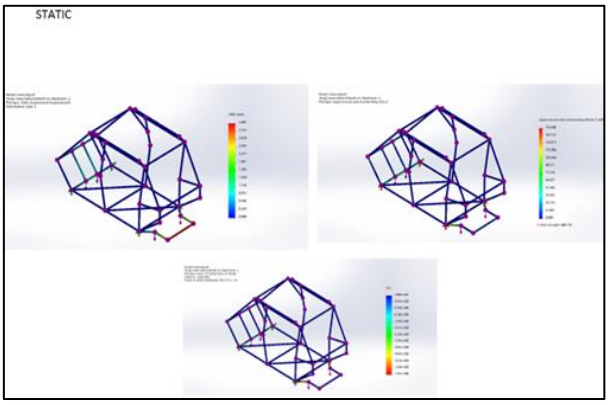

Fig. 6: Simulation Result for CEW C3

V. RESULT & DISCUSSION

Economic analysis comparison of S-rickshaw & E-rickshaw
If we compare the economic aspect of hybrid rickshaw with the normal electric rickshaw we can easily see that hybrid rickshaw has a clear edge over the other.

PARAMETERS	E-rickshaw	Hybrid rickshaw
Initial investment	125000	225000
Daily electric expenses on battery	150	35
Daily income with 8 hr. application	1300	1300
Net daily profit	1150	1265
Breakeven time period(days)	140	200
Annual operation cost	75000	30000
Annual saving comparison	399500	431725

Table 3:

Material	ERW C1		Total deformation (mm)	Factor of safety (MIN)	CEW C3		Total deformation (mm)	Factor of safety (MIN)	AISI 1018		Total deformation (mm)	Factor of safety (MIN)
Tests	YS (MPa)	Max Stress			YS (MPa)	Max Stress			YS (MPa)	Max Stress		
Static Bending	200.05	154.45	3.4	1.3	400.11	154.68	3.40	2.6	349.99	154.57	3.32	2.1

Front Impact		384	22.512	0.83		242.2	22.54	1.7		241.6	21.89	1.4
Rear Impact		340.5	19.2	.59		343.07	19.34	1.2		342.70	19.34	1

Table 4:

VI. CONCLUSION

The analysis is processed in static and structural conditions. All three materials are compared on basis of static structural bending, front impact test and rear impact test. Out of three the two material CEW c3 and AISI 1018 perform above the present material used .We would suggest to use above two material in place of ERW to fabricate the chassis.

VII. FUTURE SCOPE

Several studies that can be carried out in the future to improve the accuracy and coherency of this work are:

- Chassis can be tested with material like ASTM grade 80 etc.
- Chassis design can be modified according to different application
- Chassis can be modified to increase its torsional rigidity.
- Any desired shape of the car body can be designed.
- More tests such as bending and torsion combined, side crash test, roll over test can be performed.

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