Design of a Three Wheeler Electric Vehicle: A Review

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***Abstract*: This research paper aims to undertake a comprehensive study of the battery operated e-rickshaws. Auto rickshaws are small, three-wheeled vehicles which are used extensively in many Asian countries for transport of people and goods. In India, auto rickshaws are commonly used as they are not very expensive to operate. Despite the advantages in the vehicle design, auto rickshaws present a huge pollution problem in major Indian cities. This is because of the use of inefficient engine, a 2 or 4 stroke. These vehicles create more pollution as there is not such regulations on them and also a very large population of the country rely on these vehicles. This paper presents a transportation system for auto rickshaws that can operate in an environment friendly way. The existing vehicles are replaced by an all-electric components which are redesigned in a manner which will improve the efficiency of the vehicle. Thus looking at the existing Vehicle and the environment in which it operates, we have produced a Prototype electric vehicle.**

Keywords: Powertrain, Chassis, Bodywork, Suspension, Steering, Battery, Desigining, Three wheeler.

1.Introduction

India today is one of the top ten automotive markets in the world and given its burgeoning middle class population with buying potential and the steady economic growth, accelerating automotive sales is expected to continue. In the last couple of years, there has been a lot of discussion around the prices of fuel – apart from the deregulation of petrol prices. Moreover, the threat of disruption of supplies from the Middle-East has led to the increase in the debate on energy security, this has resulted in the use of alternate drivetrain technologies. The potential for alternative technologies in automobiles such as electric vehicles (EV) in India, depends on improving battery technologies, driving ranges, government incentives, regulations, lower prices and better charging infrastructure. There seems to be a lot of interest on the part of Internal Combustion Engine (ICE) based manufacturers to adopt electric technology, not just supplemental to the ICE, but as a stand-alone offering. There are also specialized EV manufacturers that have come up all over the world.

While many of the factors that influence the EV market are understood intellectually, we carried out a consumer survey to study the requirements and expectations of potential for electric vehicles (EV) and hybrid EV. Analysising future demand for electric vehicles was somewhat challenging as it meant testing consumer preferences for a product with which they are largely unfamiliar. For this reason, we focused on making the consumer familiar with EV technologies and products; with their opinions around price, brand, range, charging, the infrastructure, and the cost of ownership; and with the consumer's imagined "fit" of an EV in his or her lifestyle given a range of demographic parameters.

In recent years, rickshaw companies have come out with alternative models which use Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) as fuels in order to reduce the pollution problem caused by traditional petrol models.

The best way to redesign the rickshaw is to make the main power source renewable. Rickshaws are an ideal choice for electrification due to the low speed range of the vehicle and a relatively small distance that they cover. Therefore, we have set out to make auto rickshaws the example of environmental consciousness in India by replacing the existing hydrocarbon- powered vehicles with electric vehicles and recharge the batteries using mostly renewable energy sources.

2. Literature Survey

2.1 Literature Survey on Powertrain System:

Sharad Patel [1] designed and analyzed three wheeler campus mobility vehicle and concluded that after doing all the analysis and design calculation the design is safe against corresponding various load conditions. Various parameters were noted after testing to evaluate vehicle's performance. The model satisfies the primary requirement of campus mobility.

Ashish Kumar Singhal [2] conducted research on Solar/Electric Powered Hybrid Vehicle (SEPHV) and its energy usage which is stored in a battery by charging it from a solar panel. The charged batteries are used to drive the motor which replaces the role of an engine and moves the vehicle in all the directions. The performance of SEPHV was found to be satisfactory for the load of four people by testing it with an average speed of 40 Km/h.

Sharada Prasad N [3] identified the major challenges for HEV design which were managing multiple energy source, highly dependent on driving cycles, battery sizing and battery management. Electric scooter prototype was developed with design and analysis. Real time traffic and speed were recorded for further analysis. S.M.H.S.

Omar [4] presented a series of analyses to design, optimize and control the performance of a powertrain FC electric vehicle to be used in participating in energy-efficient races. Several experiments were conducted beforehand regarding controlling the vehicle, FC efficiency testing, vehicle dynamics modeling, track mapping analysis, DC motor characteristics and driving strategy techniques. These ensured the optimized sizing of the powertrain system for the vehicle and that the vehicle was controlled automatically to operate at maximum efficiency in each part of the powertrain system.

Parag Kulkarni [5] demonstrates the growing need for sustainable transportation in the World and the role of HEVs as a possible solution in the paper. Through technology review and comparative analysis it shows that HEVs can significantly reduce harmful emissions of gases. This paper summarizes the key initiatives and features of Hybrid Electric Car adapted by the world to encourage the purchase of fuel-efficient vehicles, particularly hybrid electric vehicles.

2.2 Literature Survey on Vehicle Dynamics System:

D. Vdovin [6] showed that automation of maximum quasi-static loads calculation (using two-way connected MBD and CAD-model) and automatic loads transfer to FEA allows saving time costs for full geometry-loads-stress evaluation cycle. This significantly reduced time costs for cyclic loads and stress recalculation due to frequent geometry update. There was increase in loads and stress simulation accuracy and reliability.

Goran Vukelic [7] performed analysis on a single coil spring removed from a vehicle after failing in service. They did visual observation, studied the spring material and did the microscopic analysis. Findings suggested that it was an example of corrosion fatigue failure.

Santosh Ukamnal [8] designed a trail arm suspension. They did the mathematical modeling and arriving at Optimum Values of Spring and Damper Coefficient. They made the Static Geometry for Trailing Arm and performed the Kinematic Analysis of Trailing Arm Suspension using LOTUS software. They found that soft spring gives good comfort. Very less and very high damping values gives more acceleration.

Shivam Setia [9] designed double wishbone suspension for a 3 wheeler. They evaluated the hard points by plotting various parameter curves. They used LOTUS software to find thee compliance. The spring, damper and wishbone were designed using load analysis. They it supports the vehicle weight, separates the vehicle from road disturbances, and maintains the contact between the tire and road surface and also improves the ride and handling stability of the vehicle and provide resistance to all impact loads.

Karthik Dhayakar [10] they designed and analyzed front mono suspension in motorcycle. They performed the calculations, made the cad model, selected structural steel as the material and performed the calculations. They found that the weight was reduced and the design was safe.

Venkate Karanam [11] presented Study of wobble Mode stability of 3 wheeled vehicle. Then he also studied Steering Oscillation by Rigid Body Model method and studied Wobble Stability by using Variation of Wobble Model Damping methodology. They found that Steering Column Flexibility may be

one of the main reason for these. Analysis result shows that the damping of this mode is low but positive up to the maximum speed of the Three Wheel Vehicle.

P. Deepak [12] presented the design of trailing arm and swing arm by using Adams and Ansys software also equivalent stress value are determined for safe design by using Ansys software. From these they founded that the Structural Analysis of Trailing arm and Swing arm shows that the maximum equivalent stress is less than the Yield Strength of the 1090 Mild Steel.

Palash Patodi [13] Presented where the passengers sit, the location of the engine, and the placement of other critical mechanical components, this means the car either has two wheels up front and one in the rear or Vice versa By Experimental method and also by Different Parameters. It was concluded that having one wheel in front and two in the rear for power reduces the cost of the steering mechanism, but greatly decreases stability.

2.3 Literature Survey on Brakes System:

Amit Phatak [14] did all analysis into account shows an easy to way to reduce squeal of Brake to shift Natural frequencies pattern by increasing stiffness. Considering with rib structure of Backplate shows improved results.

Phadnis Swapnil S [15] showed that as the vehicle is used as per prescribed and no excessive braking is occurred and no rough driving and intense application of brake is avoided and continuous and sudden application of brakes is also avoided as driving is smoot. The microstructure analysis revealed that there was uniform distribution of Type A graphite Flakes in Pearlite matrix and the whole microstructure is grey cast iron.

Meenakshi Kushal [16] proved that the CE (Controlled Expansion) alloy brake drum has less weight, less deformation, minimum temperature at the surface. Hence, the CE (Controlled Expansion) alloys can be a better candidate material for the brake drum applications of light commercial vehicles.

Gowthami [17] did analysis of drum brakes where it was concluded that the maximum temperature attained by aluminum alloy brake drum is 32.83°C which is less compared to the maximum temperature prevailing in cast iron brake drum and stainless steel 304 brake drum. Aluminum alloy material is proved better than the other materials considered in this investigation.

Bako Sunday [18] shows that more heat is transferred and dissipated from the brake drum. This is enhanced by the extended surface (fins) on the surface of the brake drum. Therefore the conversion of one-fourth of the overall height thickness of the original model to fins (extended surface) has also improved the heat dissipation of the modified brake drum.

2.4 Literature Survey on Chassis System:

M. H. Khan [19] explained that systematic approaches on the material selection for rickshaw frames were applied by cost per unit and weighted property method using modified digital logic. Ashby's material selection charts were used for preliminary material selection and relative cost analysis. Physical and mechanical properties and the main failure parameters were identified in the frames. The causes of failure for the rickshaw frames were Fatigue, associated with corrosion and impact load. Stress analysis on the frame system was done and for the selection of materials, the constraints were identified with the help mathematical models. Magnesium alloy, Titanium alloy, Steel, Aluminum alloy, CFRP, KFRP and GFRP were the initial selection. Among the selected materials, CFRP attained the highest performance index. However, commonly used steel was found to be the optimum for rickshaw frames followed by aluminum alloy and KFRP. The study gave the following concluding statements: 1. Steel is the optimum material for the rickshaw frame system. 2. Aluminum alloy and KFRP can be used next to steel in terms of figure of merit for the frames.

Mohammed Noorul Hussian [20] presented static analysis of chassis frame of electric tricycle. The model is created using CATIA V5 and imported to ANSYS 12 for static structural analysis. The stress plot includes Von Mises stress and shear stress along with displacement plot. The results are compared with analytical, calculated using bending of beam theory. The analysis is processed in static and structural conditions. The highest shear stress occurred is 75.571 MPa by FE analysis .The calculated maximum shear stress is 81.9752 MPa.

The result of FE analysis is 7.81 % lesser than the result of analytical calculation. The difference is caused by simplification of model and uncertainties of numerical calculation .Maximum displacement occurred at roof member as it is free end.

Amol Badgujar [21] stated that when input is provided to a three-wheeler it becomes a motion disturbance vibrating system with the ground. The tires which are in contact with the ground, convert this input displacement into a forcing function that force acts on the un-sprung masses, linkages will constrain these masse so that they follow certain paths. Ride response will vary with variation in the tires, suspension characteristics, the ground profile, physical dimensions and the inertial properties of the sprung and unsprung masses of the vehicle. Analyzing the dynamic behavior of vehicle using Finite Element modeling is the main objective of this thesis. This project also includes the response of the three wheeler chassis frame to road surface inputs and to provide the best vehicle in vibratory motions. In FE modelling, analysis is done to understand the dynamic behavior of the vehicle in Harmonic and Transient excitations. Parametric study and modal analysis was also carried out.

M. Anudeep [22] presented a complete drawing and drafting of hybrid solar car have been prepared using CATIA V5R19 software. After complete analysis of this drawing by using ANSYS 14.5 it is find out bear capability of load, stress, and strain of front & rear collision of car frame. A completed data is analyzed to examine the technical aspects of the hybrid car technology. Suitable design based analysis of hybrid solar car has been given and results of battery bank and sizing, total area of car which can be used in PV array, capacity of total load and analysis of car body have been tabulated.

Rahul Shinde [23] presented an electric car chassis design by using the commercial design software package, CATIA V5 R19. The design of the chassis with adequate stiffness and strength is the aim of this project. The material used is mild steel AISI 1018 with 386 MPa of yield strength and 634 MPa of ultimate strength. The result shows that the critical point of stress and displacement occurred in the middle of the side members in all loading conditions, maximum stresses are below the yield stress. The final products for the design have been fabricated successfully. The development and application of the finite element analysis considerably reduce the chassis design process. The chassis was designed so as the vehicle can withstand the loads with a specific strength. The simulation analysis results have established approving outcome in term of Von-Mises stress values and deflections for different loading tests. In most loading conditions, maximum stresses are below the yield stress. The final products for the designs have been fabricated successfully.

2.5 Literature Survey on Bodyworks System:

L Girisha [24] investigated about the damping properties in aluminum based hybrid nanocomposites. Commercial purity Aluminum as a matrix, Multi Walled Nano Carbon Tube (MWCNT) and Graphene (GR) as reinforcement with a weight percentage of 0.5%, 1%, 1.5%, 2% have been fabricated by Casting and Powder Metallurgy (P/M) techniques. Free vibration test was conducted. The results revels that, Al/MWCNT/Gr (1.5 wt. %) by P/M technique is having better damping properties.

Dr. Pravin M. Ghanegaonkar [25] has explained about the effect of aerodynamics on small vehicles. A study on the wake zone produced behind the vehicle was done. Simulations were done on a prototype design to reduce the drag created behind. The goals were achieved by incorporation a spoiler which reduced the chances of formation of turbulence of air flow.

Arvindakarthika K S [26] gives a study on the reduction of drag in vehicles by using aerodynamic shapes. Three basic models were made and analysis was done. There is a significant change in the coefficients of lift and drag of the model vans when a more streamlined body design is adopted.

Conclusion:

The various softwares used to design the 3 wheeler electric vehicle makes it easy to understand its behavior in various condition. Softwares such as solidworks, ansys, etc helps in achieving the desired design.

Future Scope:

Though there are many electric vehicles in the market but there is not much change in their design

and manufacturing in the area of safety and optimization. Further study on their design optimization will help to improve its safety factor and also make is more reliable.

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