Finite Element Analysis of Electric Golf Cart Chassis

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ABSTRACT

The automotive chassis is an important part of an automobile. The chassis serves as a framework for supporting the body and different parts of the automobile. Also, it should be rigid enough to withstand shock, twist, vibration, and other stresses. Along with strength, an essential consideration in chassis design is adequate bending stiffness for better handling characteristics. So, maximum stress, maximum equilateral stress, and deflection are essential criteria for the design of the chassis. This report is the work performed towards optimising the automotive chassis with constraints of maximum shear stress, equivalent stress, and deflection of chassis under maximum load. Structural systems like the chassis can be easily analysed using finite element techniques. sensitivity analysis is carried out for weight reduction. So a proper finite element model of the chassis is to be developed. The chassis is modeled in PRO-E. FEA is done on the mode-led chassis using the ANSYS Workbench.

1. INTRODUCTION

The chassis is considered as a central frame of the vehicle which has to carry all the components and support all the loads. These loads include the weight of each component and the forces which occur during acceleration. deceleration, and cornering. The chassis should be rigid enough to absorb the shock and twist. vibration and other stresses. The critical consideration for chassis design is resistance to bending and torsional stiffness apart from strength for better handling characteristics. The behaviour and stress distribution of medium-duty truck frame under dynamic conditions was studied. Where mostly used in all forms of cars and light commercial vehicles. In Semi Integral frame, half part of the frame is fixed on the front side to which the engine gearbox and front suspension are mounted. Sub-frame chassis of a dump truck which is used in mining operations were analysed for fatigue crack occurrence. Over the last three decades, there has been an increasing requirement to lower vehicle mass. This has been driven by two factors; increasing petrol prices due to shortages in the supply of crude oil and increasing awareness of the environment and the need to reduce exhaust emissions. Lowering the mass leads to less energy being required from the motor to accelerate and drive an automobile. These lower energy requirements mean emissions and petrol usage from a lighter vehicle will be less than for a heavier comparable car. The automobile industry's drive for lower vehicle emissions and energy consumption has led to the development of alternative means of propulsion, in particular Battery Electric Vehicles (BEV). The improvements have increased battery energy density which allows substantial improvements to the driving range. The increasing range allows electric vehicles to be driven like conventional internal combustion engine vehicles. There are a lot of advantages to driving an electric car. The first thing that is considered is that electric vehicles don't pollute the atmosphere although the power plant producing the necessary electricity is likely to somewhat polluting. More and more power plants are looking for more efficient ways of using solar panels, though. Bottom line is that electric cars are environmentally friendly: no exhaust fumes come out of them. They are also quite an energy efficient 7 electric motors manage to convert around 75% of the chemical energy from their batteries to power the wheels of the car, while internal combustion engines only converted about 20% of the energy that could be provided by the gas. Electric motors are also quiet and they don't require a lot of maintenance. This study was undertaken as a project to design and construct a lightweight chassis for an electric car with a capacity of 6 passengers. To design an electric vehicle, the chassis must be designed based on the requirements and the ability of the electric energy. The components involved in building the electric vehicle must be considered. The main components that will give affect the design of the chassis are the electric motor and the battery. The size, weight and the position of these components must be considered before designing the chassis. Chassis in Vehicles The chassis is the main structural frame of an automobile. It connects all key components including suspension and drive train. There are five main functions of chassis; to provide an area for occupants and luggage, offer safety to the occupants and outside parties, provide points for mounting of suspension and drive train, and provide a stiff framework linking all mounting points. The mounting of components must be rigid as large movements may cause components to interfere and thus not function intended. This section covers the function of a chassis, the different types of chassis. From the review, a suitable chassis for the electric car will be designed. Ladder Frame Chassis: The ladder frame consists of two longitudinal beams with multiple cross members joining the beams. It is versatile as allows virtually anybody shape to be placed a top the chassis

1.1 Problem Statement:

i. After our visit to Lakshya Motors Pvt Ltd, we had a discussion with the owner Mr. Ashirva Bhagat on 25th Aug 2022. The following points were summarised for carrying out our work.

ii. Chassis made for six seater golf cart which has been delivered to Viraj constructions site at Govind Nagar has shown deformation which at this stage is not considerable. So, analysis has to be performed before any further development.

iii. Some points where mountings have been provided should be clearly monitored as the hinge where the battery pack was mounted has shown cracks.

iv. At 25 kph some vibrations are noted which are to be analysed

1.2 Objectives:

1. Analysis of Electric golf cart chassis
2. Calculation of maximum stress
3. Calculation of maximum strain 4. Calculation of Deflection

1.3 Use of ANYSYS

! To reduce the damage of chassis
! To reduce the weight of chassis
! Analysis of chassis in weight and impact of temperature

2. LITERATURE REVIEW

Rohan Y. Garud, Shahid C Tamboli [ISSN 0973-4562 Volume13; 2018] "Structural analysis of automotive chassis, design modification, and optimization" From the optimisation carried out of the chassis, it can be concluded that an advanced high strength steel chassis shows a better result as compared to the original thick steel chassis. Also from the weight reduction point of view, a change in geometry topology was carried out by changing the box section to the T section from cross members [1]

K. Rajasekar Dr. R Saravanan [ISSN 2348- 7968 Volume 1; 7 Sept 2014] "The chassis design of on-road heavy vehicles" The present study has analyzed the various literature. After a careful analysis of various research studies conducted so for it has been found that sufficient studies have not been conducted on the variable section chassis concept. Hence in order to fill the gap future research studies may be conducted on the variable section chassis concept in automobiles. [2]

Vijayan S.N. Sendhil kumar [Vol7,15697-15701,May 2015] "Design and analysis of automotive chassis considering cross-section and material" [PAGES 279-284] The existing heavy vehicle chassis of EICHER is considered for design and analysis with different cross-sections for different materials like S-Glass Epoxy composites is performed. The model of the chassis was created in Pro-E and analyzed with ANSYS for the same load conditions. After analysis comparison is made between existing conventional steel chassis and S-Glass Epoxy composite materials in terms of deformation and stresses, to select the best one.[3]

M. Z. A Rashid, Marian Sulaiman [ISSN 1913- 1844, Volume no.9, 2015] "Design and simulation study of small four-wheel vehicle chassis for a single driver" This paper has presented a design for a four-wheel chassis design that can be occupied or driven by a single driver. The chassis structure selected is the space frame type chassis. A static test is also performed on the chassis design using the simulation function in the Solid works software. Then, the basic chassis frame structure is fabricated using the materials selected which is the 25mm x 25mm square mild steel with a 11 thickness of 1.6mm. The static test conducted using the simulation function in Solid work software determines the Von Mises stress, resultant displacement, and equivalent strain experienced by the chassis frame structure. In the static test, the finest available mesh is chosen to increase the accuracy of the result obtained. Then, the results obtained are analyzed and discussed.[4]

R. K. Kawade Mohan N S. [Volume.3, Issue 8, 2015] "Chassis Frame Torsional Stiffness Analysis" Finite element analysis can effectively solve the torsional stiffness analysis of the chassis frame. Two methods of stiffness analysis are carried out considering the wheelbase of the vehicle and considering the spring bracket loading. According to the comparison of simulated results spring bracket method is closer to the vehicles actual running condition and it is also evident that which higher than the wheelbase method. Spring Bracket method stiffness can be used in the vehicle handling analysis for increasing the accuracy of the results and also it will help to reduce the weight of the chassis frame by reducing the stiffness if it is higher than the required. [5]

Himanshu Hiraman Rathod, Sanjay Kumar, Vinit Goel. [Volume .4, Issue 3,march 2018] "Analysis and Design of Vehicle Chassis and its Materials" The properties of various alternate materials like carbon fiber, aluminum alloy, and titanium have been studied and compared with conventional mild steel. After a careful analysis of various research studies conducted so far, it has been found that sufficient studies have not been conducted on variable section concept and trailer chassis. To predict the life of a chassis there is a need to research the base material for the load variation and impacting static as well as dynamic. To fulfill the gap, future research studies and analyses should be conducted on variable section chassis and trailer chassis concepts and also the material to be used in automobiles.[6]

Evangelos Ch Tsirogiannis, Georgios E Stavroulakis and Sofoklis S. Makridis [31Jan,2018] "Electric Car Chassis for Shell Eco-Marathon Competition": Design, Modelling, and Finite Element Analysis Electric cars are becoming a promising solution for the near future. Hence, this work thoroughly explains design, modeling, and simulation processes for an electric car"s chassis. The criteria of comparison for the best electric chassis design at the Shell Eco-Marathon are the weight, the strength, the ergonomics, and safety. The proposed electric car chassis is synonymous with lightweight engineering because of being the lightest chassis in the competition while it obeys ergonomic and safety rules. The innovation of this research work is the overcoming of the time-consuming process by using the chassis load calculator (CLC) model suitable for an electric car. Furthermore, the methodology for the processing procedure through FEM, which was developed under a combined stress scenario and by using the exact vehicle"s dynamic loads, would be suggested as an accurate ultrafast method. In the future, further studies with more loading cases and further optimization of dimensions and materials will be followed. [7]

Ameya Dabhade, Khizar, A.Pathan [ISSN 0976-6480 volume11, issue 10 Oct 2020] "DESIGN AND DEVELOPMENT OF CHASSIS FOR FORMULA STUDENT VEHICLE" The manufactured design of the chassis satisfies all the objectives decided at the beginning. All dimensions of the three compartments viz. front, driver, and engine are the same as designed. Because of the kind of fixture developed, it saves a lot of manufacturing and protects the unnecessary investment in steel fixtures. Physical ergonomics gives crucial data about the positioning of different components and visibly aspect to a driver before complete manufacturing and assemblage of the vehicle.[8]

Kenji KARITA, Yoichiro KOHIYAMA, Toshihiko KOBIKI, Kiyoshi OOSHIMA, Mamoru HASHIMOTO (2003) had developed a chassis made by Aluminium. The material

selected for the frame is 6061-T6. They used the Variable section extrusion method for making the chassis. It's developed with the help of computer Aided Engineering. Aluminium material gives an advantage of weight reduction. From this study authors found that the Aluminium chassis meets the target of weight reduction, strength and rigidity. Also, they concluded that the remaining technical issues will be addressed to enable commercial adoption of the aluminium frame.[14]
Alireza Arab Solghar, Zeinab Arsalanloo (2013) studied and analyzed the chassis of Hyundai Cruz Minibus. ABAQUS Software was used for modelling and simulation. Self-weight of the chassis is considered for static analysis and Acceleration, Braking and Road Roughness were considered for dynamic analysis. It's observed that the stresses on chassis caused by braking were more compared with acceleration.[13]
M. Ravichandra, S. Srinivasalu, Syed altaf Hussain (2012) studied the alternate material for chassis. They studied and analysed Carbon/Epoxy, Glass/Epoxy and Sglass/Epoxy as chassis material in various cross sections like C, I and Box Section. TATA 2515EX chassis was taken for study. Pro-E and Ansys software were used for this work. Study reveals that the Carbon/EpoxyI section chassis has superior strength, stiffness and lesser weight compared to other materials and cross section.[15]
Roslan Abd Rahman, Mohd Nasir Tamin, Ojo Kurdi (2008) used FEM stress analysis as a preliminary data for fatigue life prediction. They used ABAQUS software for simulation and analysis and taken ASTM Low Alloysteel A710 (C)for study. Primary objective was to find the high stressed areawhere the Fatigue Failure will start. It's found that the chassis opening area having contact with bolt experiences high stress.[16]
N.V.Dhandapani, G Mohan kumar, K.K.Debnath (2012) have used Finite element methods to study the effect of various stress distribution using Ansys software. To investigate the field failure of 100Ton dumper they introduced gussets in failure area. After modification the chassis structure was validated by linear static analysis and found that the modified chassis was safe.[17]

3. METHODOLOGY

The method overview begins with creating a CAD model for the initial design of the chassis using design methodology rules.
• This initial design is subjected to FEA to determine whether it meets the acceptance criteria.
• The design is then modified further by creating lightweight cross members. Modifications are made to chassis made of various materials to make it light weight until the design meets the acceptance criteria.
• The final chassis selected is optimised to reduce weight by optimising thickness.
• If the optimisation of thickness is successful for the chassis chosen, the design is possible.
• The acceptance criteria for the optimised chassis are therefore rechecked. If the optimisation of thickness fails, the design is considered as a chassis which cannot be implemented.
• The chassis is therefore reconstructed. The whole process goes from post-processing through the optimisation of thickness to checking criteria for acceptance until the chassis design is feasible.
• Depending on the following factors additions and modifications can be done to the chassis in terms of cross members, Strength: Chassis should have a high strength to maintain stability. It should also have the capacity to withstand the weight of 30 components and other loading conditions. So, to improve the strength of chassis, few cross members can be added.

3.1 DESIGN AND ANALYSIS OF CHASSIS STRUCTURE

CATIA part design and generated structural analysis will be used in the design analysis optimisation process. ANSYS workbench will be used for carrying out analysis of structures

BASIC CALCULATION FOR CHASSIS FRAME

• Material of the chassis is mild steel • E = 2e+11 N/mm*mm
• Poissons Ratio = 0.266
• Density = 7860 kg/m*m*m
• Capacity of the vehicle is of 6 person i.e. About 480 kg = 4708 N
• Capacity of the vehicle with 1.1% = 5178 N
• Weight of the body, Motor and Batteries = 124 kg = 1216 N
• Total load acting on the chassis is = 6394 N

3.2 Theory of load cases

A chassis is subjected to three load cases: bending, torsion, and dynamic loads. The bending (vertical symmetrical) load case occurs when both wheels on one axle of the vehicle encounter a symmetrical bump simultaneously. The suspension on this axle is displaced, and the compression of the springs causes an upward force on the suspension mounting points. This applies a bending moment to the chassis about a lateral axis.

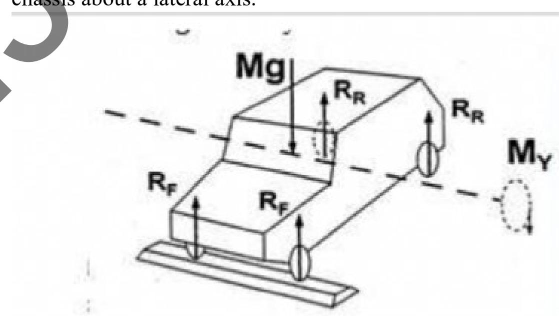

Fig 3.2.1 Reaction And Load of chassis

The torsion (vertical asymmetric) load case occurs when one wheel on an axle strikes a bump. This load is causing the chassis to torsion as well as bending. It has been found both in theory and in practice that torsion is a more severe load case than bending. The dynamic load case comprises longitudinal and lateral loads during acceleration, braking, and cornering. These loads are usually ignored when analyzing structural performance and this analysis will follow the free boundary condition procedures. A torsion stiffness chassis offers several advantages: 1. According to vehicle dynamics principles, for predictable and safe handling, the geometry of the suspension and steering must remain as designed. For instance, the camber, caster, and **toe angles** could change with torsion twist causing "bumpsteer." 2. Once again according to vehicle dynamics principles, a suspension should be stiff and well-damped to obtain good handling. To this end the front suspension, chassis, and the rear suspension can be seen as three springs in series as shown in If the chassis is not sufficiently stiff in torsion, then any advantages gained by stiff suspension will be lost.

3.3 OVERVIEW OF CHASSIS TYPE

The chassis used for this analysis is Golf cart Chassis as shown in Fig 3.1. and it was described as a space frame chassis with a ladder-type structure. It is constructed from mild steel Rectangular C Section and its cross-section is supported by a mild steel sheet as shown in figure 3.3.1

Figure 3.3.1 Chasis assembly

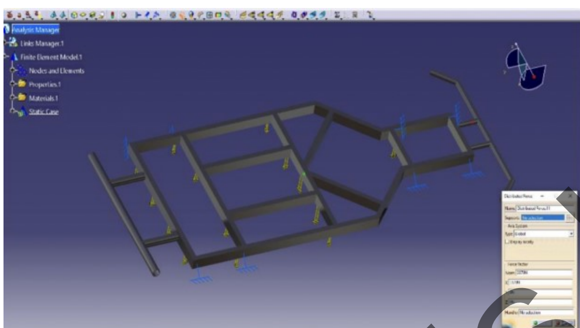

Figure 3.3.2 Catia Software

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