Design and Development of Chassis for Hybrid Electric Vehicle.

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Abstract - *The automobile chassis is the foundation for internal components and external loads, influencing vehicle performance. Advancements in design and construction have improved speed, handling, safety, and fuel economy. The evolution of chassis systems, originating from Henry Ford's assembly line, has been marked by technological leaps, particularly in lightweight materials and innovative designs. This research aims to provide insight for student teams in automotive competitions, facilitating the creation of efficient, high-performance chassis for hybrid electric vehicles, by examining various materials and design approaches.*

Key Words: Hybrid electric vehicle, Chassis, Design, Manufacturing, analysis, testing, Material Selection, Impact Analysis.

1.INTRODUCTION

The automobile chassis is the structural foundation of a vehicle. It is the main supporting system of the vehicle which supports the internal components of the vehicle and also sustains the load acted upon it due to this integrated component and also the extra weight putted on the vehicle. The automobile chassis play an important role in developing the vehicle and the performance factors that would be achieved by a automobile. Its design and construction influence the vehicle's handling, ride comfort, and durability. Due to certain advancement in the development of chassis system the performance factors like speed, handling, safety, fuel economy has been improved considerably. The chassis frame supports the various components and the body and keeps them in correct positions. Our attempt is not entirely correct way to design a chassis system, but it is an honest effort to design a chassis for a Hybrid Electric Vehicle (HEV).

1.1 History

As we know that Automobile Industry is an evergreen industry and it has seen several advancements in recent time. At the time of the first Mass Production Assembly Line Started by the great Henry Ford on December 1st 1913. From that time several automobile manufacturers are trying different things and introducing several technologies in order to increase the production and to make their vehicles more durable and powerful. One such system that have seen a swift technological and manufacturing advancement is the Roll Cage or Chassis system. The chassis of an automobile has been an important part for the manufacturing companies since it supports all the other components that are to be fitted into the vehicle, It was like the foundation of the main vehicle. In order to make the foundation strong several materials, different shapes of the materials, and different types of chassis was used. This all factors resulted in improvement of the chassis and due to which the vehicle became more durable and robust, but as the time passed several performance factors was demanded from the automobile by the people, like better fuel consumption, Increasing speed, more aerodynamic shape, overall light weight vehicle this all-demand lead to the development of chassis system. Several light weight materials were tested in order to replace the heavy materials so the overall weight of the vehicle would reduce, which would result in better fuel efficiency and better speed. Some material of equal strength but of less weight than the original materials were used. Also, different types of chassis system were developed like single frame ladder chassis, double frame ladder chassis, tubular chassis, monocoque chassis etc.

1.2 Some Drawbacks in current model(from analyzing current model)

The automobile market has significantly changed, with the replacement of conventional petrol and diesel vehicles by electric vehicles (EV) and hybrid electric vehicles (HEV). The manufacturing and design approaches of these vehicles are evolving to meet the need for pollution-free vehicles. HEVs aim to provide maximum range with low fuel consumption, making weight a key design parameter. Manufacturers are working to reduce chassis weight by using different materials, with some achieving this goal. This effort aims to create a chassis that supports various components and sustains the load applied on it, ensuring efficient range and low fuel consumption. Overall, the development of EVs and HEVs is crucial for today's world.

1.2 Need of the Project:

From this project the student teams that are participating into different competition will get an idea about the different materials that can be used to manufacture chassis and how to deliberately decrease the weight of the chassis which would ultimately decrease the weight of the whole vehicle, also they didn't need to compromise on the safety parameters and the overall strength of the chassis system.

2. BASIC COMPONENTS OF CHASSIS

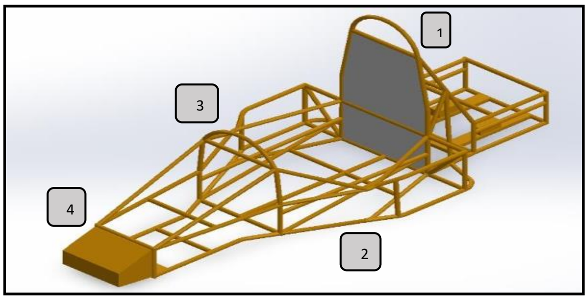

FIG.1. Layout of Chassis

The Primary Structure is comprised of the following Frame components:

1. **Main Hoop -** A roll bar located alongside or just behind the driver's torso.
2. **Frame Member -** A minimum representative single piece of uncut, continuous tubing.
3. **Front Hoop -** A roll bar located above the driver's legs, in proximity to the steering wheel.
4. **Front Bulkhead** – A planar structure that defines the forward plane of the Major Structure of the Frame and functions to provide protection for the driver's feet.

2.1 PROBLEM STATEMENT

To Design a lightweight Tubular chassis for urban Hybrid Electric Vehicle, which Sustain given load and Prioritize Drivers Safety.

2.2 OBJECTIVE

- Select materials from Design Data Book based on strength, durability, and cost, for maximum strength-to weight ratio.
- Study of different shapes and cross section of the chassis.
- Design and Fabrication of durable and reliable Chassis.
- Modelling and analysis of chassis.
- Testing of Chassis in various Static and Dynamic conditions.

3 METHODOLOGY

1. **Chassis Components and Parameters:**
Component Identification: This includes listing all the components that the chassis will support and integrate. This includes the engine, transmission, suspension, body panels, and other additional systems specific to the vehicle's purpose (such as a battery pack for an electric vehicle). This includes its dimensions (length, width, height), weight distribution and attachment points. Software like AutoCAD or CATIA helps visualize insertion and removal.

2. **Chassis Design:**
Computer Aided Design (CAD): Create a digital image of the chassis using 3D modeling software such as SolidWorks or Creo. Here, engineers consider the location of components, their dimensions, and how they will be integrated into the entire structure. CAD models allow visualization, dimensional analysis and effects of components.

3. **Material selection:**
Material selection affects case performance, weight and cost. Options include steel (high strength, suitable for conventional vehicles), aluminum (lightweight, suitable for high-end vehicles) and carbon fiber (very light, used in expensive, high-end parts). Important factors to consider are: Strength and stiffness: The material must withstand forces during operation (speed, stop, angle) without excessive deformation. and maneuverability. Equipment cost is especially important for larger vehicles.

4. **Stress Analysis:**
Finite Element Analysis (FEA) software like ANSYS or Abaqus is used to simulate the stresses and strains that the chassis will experience under various loading conditions. The 3D CAD model is virtually divided into small elements, and computer calculations predict how these elements will deform or break under applied loads. This analysis helps identify weak points in the design and optimize the material distribution for maximum strength and weight efficiency.

5. **Physical inspection:**
Prototype design: The physical model of the chassis can be designed based on the completed CAD model. The models are then subjected to rigorous testing that mimics real-world conditions:
Static load test: simulates the weight of the vehicle and cargo.

Crash test: Test the chassis' ability to protect passengers in the event of a crash. Any differences will indicate an area where the design may need to be changed.

6. **Production:**
Production Planning: Once the design is verified by testing, the production process can be planned. This includes selecting the appropriate manufacturing process (such as welding, riveting, assembly) and ensuring that the chosen method is compatible with the selected product.

3.1 IMPACT ANALYSIS

The Frame needs to withstand any collision that it might be subjected to as part of the testing process or competition. Four impact scenarios were analyzed to ensure the frame design will not fail.

- Front Impact Test.
- Rear Impact Test.
- Side Impact Test.
- Rollover Test.

(**Note:** All of this test are done in ANSYS.)

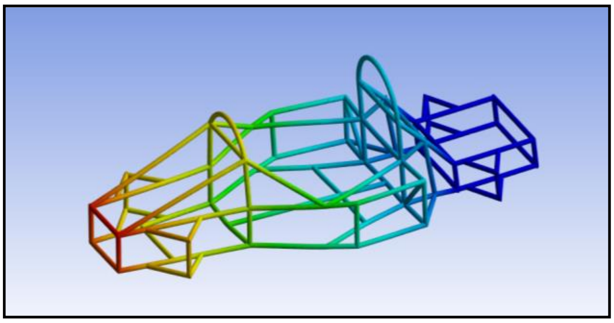

Fig. 2. Front Impact Test

The vehicle is designed for maximum speed of 80 km/ph. The total weight of the vehicle including the driver is estimated to be 320 kg. It is considered for the static analysis that the vehicle comes to net 1 sec after the impact. The Boundary conditions for this test are

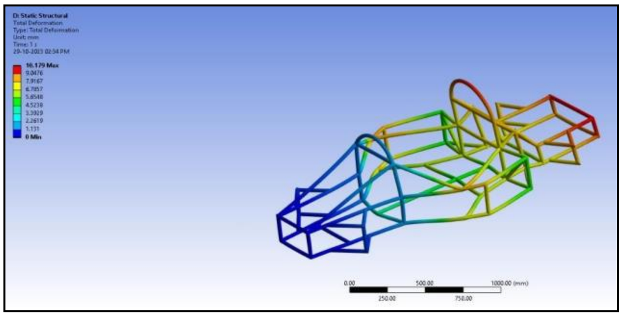

Fig. 3. Rear Impact Test

In this case the vehicle is assumed to be in rest condition and the vehicle of same mass is assumed to collide with our vehicle with the speed of 80 km/Ph, and we observe the maximum deformation in that condition.

Fig. 4 shows the Side Impact Test in which the Vehicle is in Rest Position and the vehicle of same specifications and same mass is assumed to collide with our vehicle sideways so in this condition the maximum deformation is noted and studied upon.

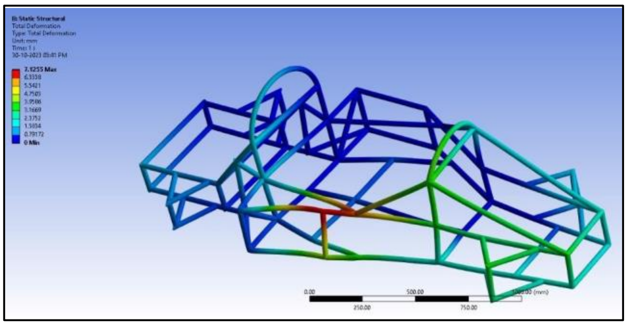

Fig. 4. Side Impact Test

After the Front, Rear, and Side Impact test we Perform the last type of test i.e. Vehicle Rollover test. In this test we assume the vehicle rollover condition and the position of vehicle is changed and the maximum force gets exerted on the main hoops Bracing.

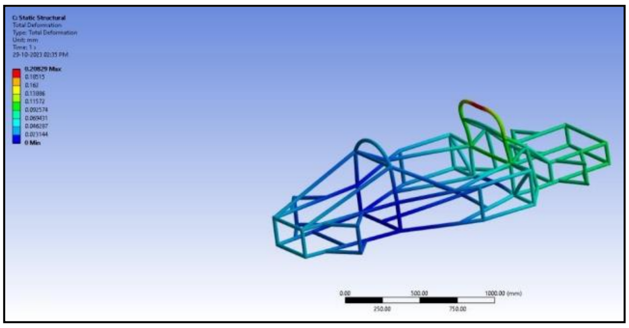

Fig. 5. Rollover Test

RESULT TABLE:

Sr. No	Scenario	Boundary Condition	Results
1.	Front Impact Test	Velocity–80 kmph	(Max.Def. =27.534 mm) (F.O.S. =2.3867)
2.	Rear Impact Test	Force = 22204 N	Max.Def.=10.179mm) (F.O.S. = 2.7433)
3.	Side Impact Test	Force = 9417 N	(Max.Def. = 7.1255 mm) (F.O.S.=3.237)
4.	Roll Over Test	Force = 6270 N	(Max.Def. = 0.2082 mm) (F.O.S. = 3.897)

Table No. 1

CONCLUSIONS

The study on the design and manufacturing of a lightweight tubular chassis for an urban Hybrid Electric Vehicle (HEV) has provided significant insights into the evolution of chassis systems in the automobile industry. The research highlighted the importance of chassis as the structural foundation of a vehicle, with advancements made to improve performance, safety, and fuel efficiency. The study also highlighted the importance of material selection and design optimization, with CAD modeling and Finite Element Analysis (FEA) simulations helping optimize the design for maximum strength-to-weight ratio. The chassis underwent comprehensive testing, including static load tests, impact scenarios, and roll-over tests, providing valuable insights into its performance under different conditions. The designed lightweight tubular chassis demonstrated enhanced performance attributes, such as improved speed, handling, and fuel economy, contributing to the efficiency and sustainability of hybrid electric vehicles. The project also serves as a valuable resource for student teams participating in automotive competitions, offering insights into material selection, design methodologies, analysis techniques, and testing protocols. Overall, this research contributes to ongoing advancements in automotive engineering, particularly in sustainable mobility solutions and the transition towards electric and hybrid vehicles.

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