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Design and Analysis of Chassis Frame for Two Wheel Electric Commercial Vehicle

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Abstract - The chassis frame forms the backbone of a vehicle; its principal function is to safely carry the maximum load for all designed operating conditions. Automotive chassis is the main carriage system of a vehicle. The chassis serves as a skeleton upon which parts like gearbox and engine are mounted. The two-wheeler chassis consists of a frame, suspension, wheels and brakes. The chassis is what truly sets the overall style of the two-wheeler. Commonly used material for two-wheeler chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like aluminum alloys, titanium, carbon fiber, magnesium, etc. which are lesser in weight and provide high strength and thus can be used for chassis. The frame consists mostly of hollow tubes and serves as a skeleton on which components like the fuel tank and engine are mounted.
This project deals with design of two-wheeler chassis frame and its weight optimization. Various loading conditions like static loadings were carried out on the chassis and the structural stability of the chassis is analyzed by using alternate material as well as alternate geometry while maintaining the strength. Geometry modification in present chassis design by changing thickness of hollow tube. The various materials are studied and the best material will be selected as the solution. The weight optimization is achieved in this project. The 3d model of the chassis is created using appropriate modelling software. And its structural behavior is analyzed using Ansys Workbench 2022R1.

***Key Words*: Weight Optimization., Chassis Frame, Structural Stability, 3D Modelling.**

1. INTRODUCTION

The chassis frame forms the backbone of a vehicle; its principal function is to safely carry the maximum load for all designed operating conditions. Automotive chassis is the main carriage system of a vehicle. The chassis of electric bike serves as a skeleton upon which parts like battery and motor are mounted. The two-wheeler chassis consists of a frame, suspension, wheels and brakes. The chassis is what truly setsthe overall style of the two-wheeler. Commonly used material for two-wheeler chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like aluminum alloys, titanium, carbonfiber, magnesium, etc. which are lesser in weight and provide high strength and thus can be used for chassis.

The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gear box and engine are mounted. Suspension The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts. Wheels Motorcycle wheels are generally aluminum or steel rims with spokes, although some models introduced since the 1970s offer cast wheels. Cast wheels allow the bikes to use tubeless tires, which, unlike traditional pneumatic tires, don't have an inner tube to hold the compressed air. Breaks The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal.

A motorcycle frame is a motorcycle's core structure. It supports the engine, provides a location for the steering and rear suspension, and supports the rider and any passenger or luggage. Also attached to the frame are the fuel tank and battery. At the front of the frame is found the steering head tube that holds the pivoting front fork, while at the rear there is a pivot point for the swingarm suspension motion. Some motorcycles include the engine as a load-bearing stressed member; while some other bikes do not use a single frame, but instead have a front and a rear sub frame attached to the engine.

Optimization is a design tool that assists designers automatically to identify the optimal design from a number of possible options, or even from an infinite set of options. Optimization design is increasingly applied in industry since it provides engineers a cheap and flexible means to identify optimal designs before physical deployment. Optimization capabilities have also been increasingly integrated with CAD/CAM/CAE software such as Adams, Nastran, and Opti Struct. Even in our daily life, we are constantly optimizing our goals (objectives) within the limit of our resources. For example, we may minimize our expenditure or maximize our saving while maintaining a certain living level. When shopping for a car, we may try to meet our preference (performance of the car, safety, fuel economies.) maximally on the condition that the price doesnot exceed what we can afford. It is the same case in engineering design where we optimize performances of the product while meet all the design requirements.

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2. PROBLEM DEFINATION AND OBJECTIVES

2.1 Problem Definition

Vehicle chassis play important role in the performance of any vehicle. Continuous efforts are made to reduce weight and cost of vehicle by modifying chassis design. There is scope in modification of chassis design of present motorcycle. Weight reduction and smart chassis is required for two-wheeler is required for two-wheeler to improve its performance with reduced cost. While modifying the design weight is to be optimized keeping same strength and other properties.

2.2 Objectives

1. To study the current system in detail with its specification and all required considerations of a motorcycle.

2. To design, optimize, the existing material for existing chassis to minimize the overall weight of it, to save considerable amount of material.

3. The optimization of system will be according to one of the following cases: Changing dimensions of system and keeping material same as it is. Keeping same dimensions and changing material of components,

4.Changing both material as well as dimensions of component. The modeling of new design with help of SOLIDWORKS software. To analysis of the redesigned new chassis to studythe stress on the system.

3 CHECK DESIGN AND FINITE ELEMENT ANALYSIS OF CHASSIS.

3.1 Check design of chassis 1.

The Modified chassis have been used in this project.
Specification

Table :1. **:** Dimensions of Chassis `

Sr. No	Pipe	Dimension
1	A	O.D. = 48.30 mm I.D. = 42.76 mm
2	B	O.D. = 42.2 mm , I.D. = 36.66 mm
3	C	O.D. = 42.2 mm , I.D. = 36.66 mm
4	D	O.D. = 42.2 mm , I.D. = 36.66 mm
5	E	O.D. = 42.2 mm , I.D. = 36.66 mm
6	F	O.D. = 33.4 mm , I.D. = 27.86 mm
7	G	O.D. = 33.4 mm , I.D. = 27.86 mm
8	H	O.D. = 33.4 mm , I.D. = 27.86 mm
9	I	O.D. = 33.4 mm , I.D. = 27.86 mm
10	J	O.D. = 33.4 mm , I.D. = 27.86 mm
11	K	O.D. = 33.4 mm , I.D. = 27.86 mm
12	L	O.D. = 33.4 mm , I.D. = 27.86 mm

3.2 CAD Model of chassis 1 :

Modelling of the existing 1two-wheeler chassis will be by using SOLIDWORKS software and after proper modelling the analysis of system will be done using ANSYS software.

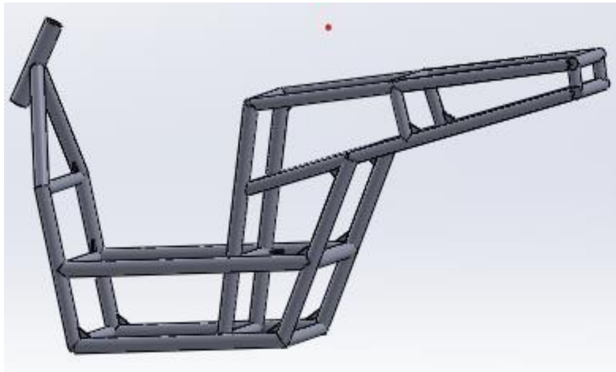

Figure 1. CAD Model of Chassis

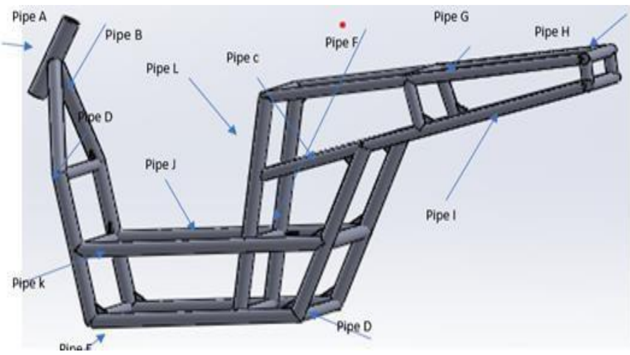

Figure 2 Nomenclature of CAD Model

Table 2: Dimension and weight Specification
Dimension and weight

Length *Height*Width	2073 x 700 x 1050
Wheel base	1340 mm
Ground clearance	190mm
Battery weight	60kg
Kerb weight	110 Kg

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3.3 Structural analysis of chassis

i) Material: Steel

Table 4. Material Properties

Mechanical property	Value	Unit
Density	7850	Kg/m^3
Coefficient of Thermal Expansion	1.3e-005	1/c
Tensile Yield Strength	550	MPa
Young's Modulus	210	GPa
Poisson's Ratio	0.3	

ii) Meshing:

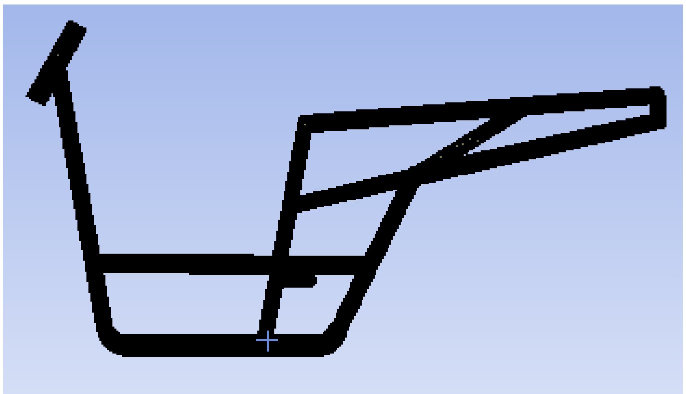

Figure 3 Meshing of chassis frame

Details of Meshing

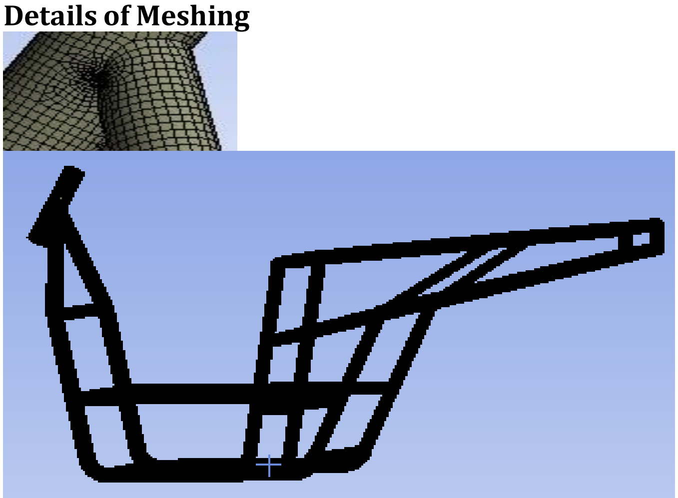

Figure 4 Details of meshing

Mesh quality check:

Table 5. Mesh quality parameter

Sr. no.	Mesh quality parameter	Required	Achieved
1	Skewness	<0.7	0.55
2	Jacobian	Ideal value 1	1
3	Warping	<30, Ideal value 0	9
4	Aspect ratio	<5	5

iii) Boundary conditions for structural analysis of chassis:

a) Fixed Support

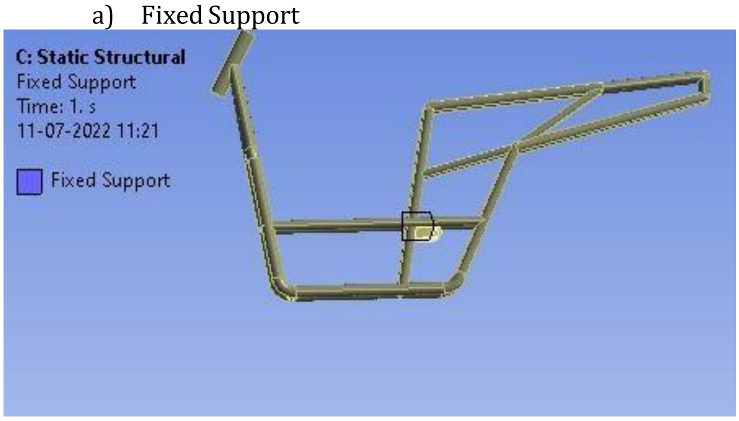

Figure 5. Boundary condition –Support

B) Remote Battery : 600N

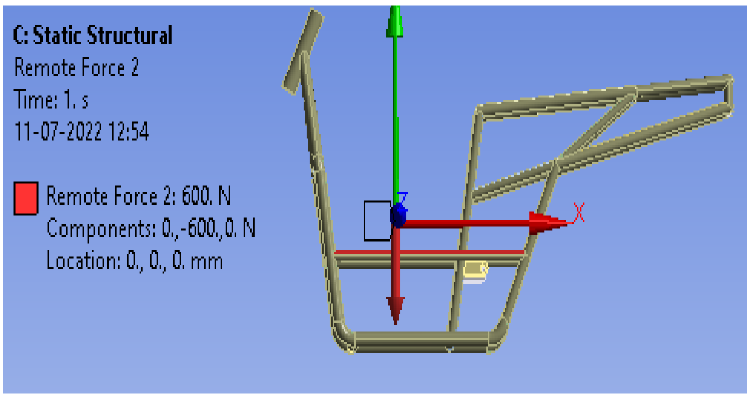

Figure 6. Boundary condition –Support

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C) Force 1 :(Riders weight 3000N)

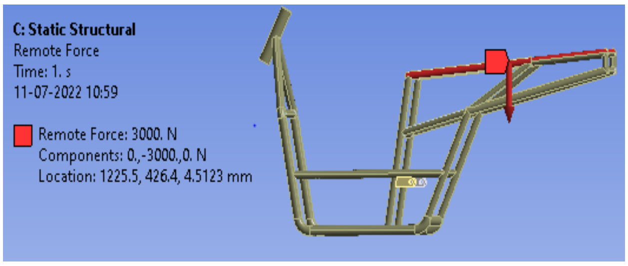

Figure 7. Boundary condition –Riders Weight

D) Force 2:(Dynamic load -600 N)

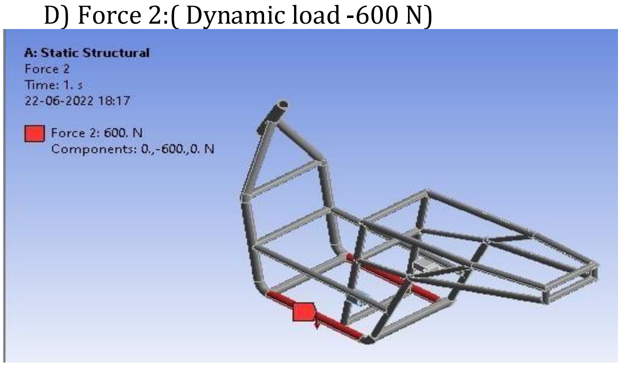

Figure 8. Boundary condition – Dynamic load

E) Force 3: Fixed Support

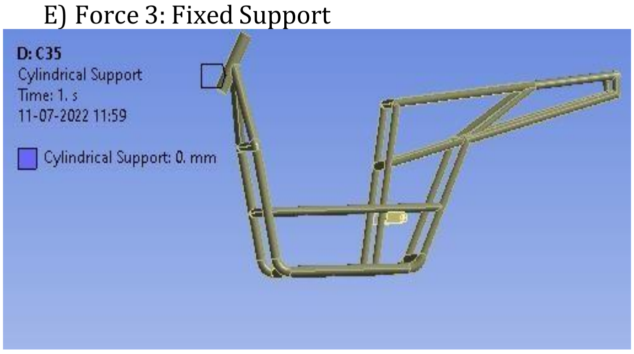

Figure 9. Boundary condition –fork

4 DESIGN OF SYSTEM FOR OPTIMIZATION:

After study of existing system, 3D modelling of chassis is done in CAD software .Analytical design calculation of existing system is also carried out . Design of that system for optimization will be started. Different pipes will be studied and various parameters like geometry and materials will be studied. Optimization of system will be according to one of the following case: Changing dimensions of system and keeping material same as it is.

Changing dimensions of system and keeping material same as it is. In this approach weight reduction is achieved by minimizing thickness of hollow chassis tube. By increasing inner diameter of hollow chassis tubes as shown in figure.

Table 6. New dimensions of chassis

Sr.No.	Pipe	Present Design	Modified design 1	Modified design 2
1	A	O.D. = 48.30 mm , I.D. = 42.76 mm	O.D. = 48.30 mm , I.D. = 44 mm	O.D. = 48.30 mm , I.D. = 45 mm
2	B	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
3	C	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
4	D	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
5	E	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
6	F	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29 mm	O.D. = 33.4 mm , I.D. = 30.4 mm
7	G	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
8	H	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
9	I	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
10	J	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
11	K	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
12	L	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm

5 RESULTS AND DISCUSSION

After the processing solutions, the contours of Von-Mises Stresses, Total Deformation, and Equivalent Elastic Strain in Static structural analysis are plotted.

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5.1 Result of design 1 of chassis

A) Total deformation

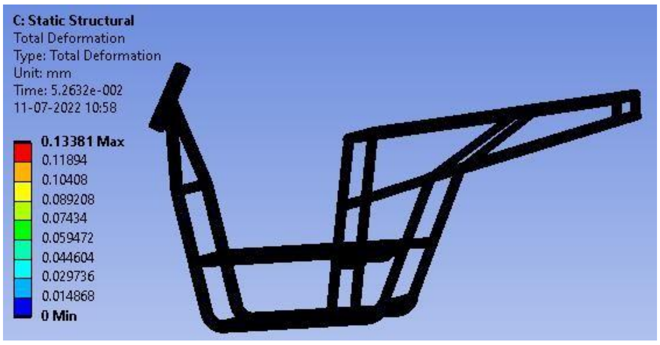

Figure 10. Total deformation

A) :Von mises stress

Figure 11. Von mises stress

5.2 Result of design 2 of chassis:

B) Total Deformation:

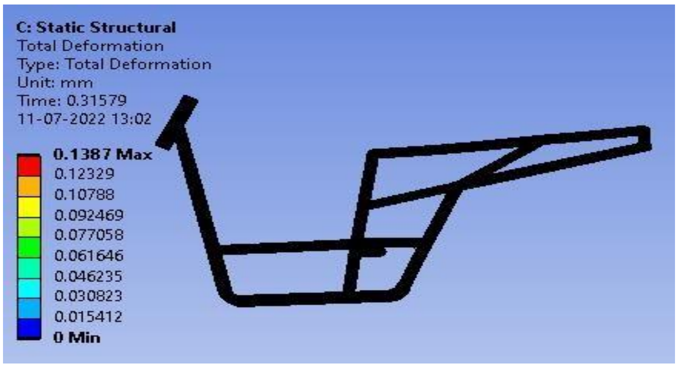

Figure 12. Von mises stress

B) Von mises stress:

Figure 13. Total deformation

5.3 Result of Optimized Design of chassis:

C) Total deformation:

Figure 14 .Total deformation

C) Von mises stress:

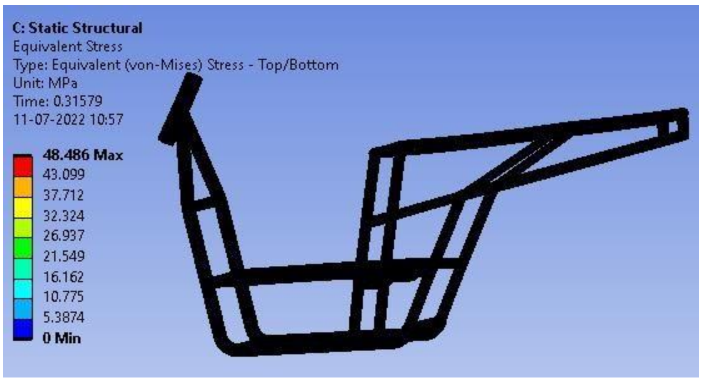

Figure 15. Von mises stress

Table 7. Result table 1

Design	Von mises stress (MPa)	Total deformation (mm)	Maximum permissible stress (MPa)	F.O.S.
Modified Design 1	84.03	0.13381	730	8.69
Modified design 2	50.377	0.1387	730	14.49
Optimized Design	48.486	0.2195	730	15.05

Von mises stress for chassis design 1 is 84.03 MPa which is below the maximum permissible stress. Hence design is safe. For weight reduction purpose we have modified the design 1. For modified design 2 and modified design 3 stress are 50.37MPa and 48.486 MPa, butthese stress values is below maximum permissible stress forsteel.

Table 8. Result table 2

Design	Weight	Weight reduction
Modified design 1	30.15 Kg	16.05%
Modified design 2	24.75 Kg	26.15 %
Optimized Design 3	17 .89kg	49.96%

6 CONCLUSIONS

Von mises stress for chassis design 1 is 84.03MPa which is below the maximum permissible stress. Hence design is safe. For weight reduction purpose we have modified the existing design. For modified design 2 and modified design stressare 50.37 MPa and 48.86 MPa, butthis stress value is below maximum permissible stress forsteel. Weight reduction 16.05 % and 26.15 % is achieved for modified design 1 and design 2.

If we compare stress value of steel with other material then we will get that stress value for steel and aluminum is almost same and stress value is lower for titanium and carbon fiber. Titanium and carbon fiber are costly material so we have eliminated this material on cost basis. In future we can develop chassis using various grade of aluminum

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