Structural Analysis and Optimization of Car Chassis

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Abstract— Automotive chassis is a French word that was initially used to represent the basic structure. It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions. Automobile chassis is usually made of light sheet metal or composite plastics. It provides strength needed for supporting vehicular components and payload placed upon it. Automotive chassis or automobile chassis helps keep an automobile rigid, stiff and unbending. It ensures low levels of noise, vibrations and harshness throughout the automobile. Automobile chassis without the wheels and other engine parts is called frame. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars that are essential parts of automotive frames are fasteners that bind different auto parts together. Automotive frames are basically manufactured from steel. Aluminium is another raw material that has increasingly become popular for manufacturing these auto frames. In an automobile, front frame is a set of metal parts that forms the frame work which also supports the front wheels. In this project we are working on a chassis of the car. The chassis of the car is having more weight. Hence the weight will be reduced and the low loading components of chassis will be studied and thus they will be eliminated of geometrically optimised according to requirement. The study of chassis having low loading components supports will be reduced.

Key words: Chassis Frame, Stress, Weight Optimization

I. Introduction

Automobile chassis is usually made of light sheet metal or composite plastics. It provides strength needed for supporting vehicular components and payload placed upon it. Automotive chassis or automobile chassis helps keep an automobile rigid, stiff and unbending. It ensures low levels of noise, vibrations and harshness throughout the automobile. Automobile chassis without the wheels and other engine parts is called frame. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars that are essential parts of automotive frames are fasteners that bind different auto parts together.

Automotive frames are basically manufactured from steel. Aluminium is another raw material that has increasingly become popular for manufacturing these auto frames. In an automobile, front frame is a set of metal parts that forms the framework which also supports the front wheels. In this project we are working on a chassis of the car. The chassis of the car is having more weight. Hence the weight will be reduced and the low loading components of chassis will be studied and thus they will be eliminated of geometrically optimised according to requirement. The study of chassis having low loading components supports will be reduced.

The automotive chassis provides the strength necessary to support a vehicle's components and the payload placed upon it. The suspension system contains the springs, shock absorbers, and other components that allow the vehicle to pass over uneven terrain without an excessive amount of shock reaching the passengers or cargo. The steering mechanism is an integral portion of the chassis, as it provides the operator with a means of controlling the direction of travel. The tires grip the road surface to provide good traction that enables the vehicle to accelerate, brake, and make turns without skidding. Working in conjunction with the suspension, the tires absorb most of the shocks caused by road irregularities.

After studying all the literature there is scope for studying the low loading components in chassis of the car. These components can be optimized for various reasons like follow:

1. To reduce the weight of chassis
2. The light weight chassis will consume less fuel and will be the cost efficient.
3. Material required to make chassis will be reduce hence the overall cost of chassis will be reduced.

For carrying out all this study, the modelling software and analysis software will be used. The optimized chassis will be analysed on software and compare with experimental results.

A. Problem Definition

The current design for vehicle chassis is a heavy weight and bulky design. This heavy loaded system causes various problems in the system. The fuel consumption and cost of the chassis became more due to this rigid design. Hence the low loaded components in the chassis of the car will be studied and the work on these components will be carried out for optimisation. The low load bearing component can be optimised for achieving various advantages like effective fuel consumption and cost-efficient system.

B. Objectives

To study the current system in detail with its specification and all required parameters of chassis and forces acting on it. To design, optimize the chassis for overall weight reduction in the system. The load bearing components in the chassis will be optimized so that overall weight will reduce. The study of different material will be done which is useful for chassis. The modelling of new design with help of CATIA software. To analysis of the redesigned new chassis to study the stress on the system.

II. CREATING GEOMETRIC MODEL AND FINITE ELEMENT MODEL OF EXISTING AND OPTIMISED CHASSIS.

A. Modelling of existing chassis

The chassis is the main part of the vehicle. The chassis is heavy in weight and hence it should be optimised according to the weight. Thus, Tavera was selected for optimisation of the weight of chassis.

Sr. No	Parameter	Values
1	Length of chassis	3963 mm
2	Width of chassis	1016 mm
3	Maximum Power	78 bhp @ 3800 rpm
4	Maximum Torque	176 N-m
5	Length of vehicle	4435 mm
6	Width of vehicle	1680 mm
7	Ground clearance	185 mm
8	Kerb weight of vehicle	1640 kg

Table 1: Specifications of vehicle

The chassis taken into a study is of Tavera. The chassis can be optimised for further study. The dimensions of the vehicle are mentioned above. The cad model of the same is mentioned below:

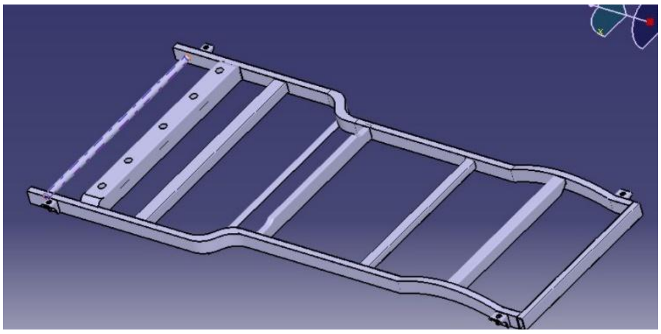

Figure 1: Geometric modelling of Chassis

B. Design of Optimised chassis

Now in changing of the existing system and calculating the new system the dimensions are changed and material is kept same. the overall length of the chassis is kept constant only thickness and width is reduced. The various dimensions are tabulated below

Sr. no.	b (m)	h (m)	T (m)	Bending stress (MPa)	Deflection (mm)	Actual Weight (kg)	Weight difference with existing chassis (kg)
1	0.051	0.102	0.005	262.4	2.28	139	0
2	0.051	0.102	0.004	253.4	2.75	122	17
3	0.051	0.102	0.003	346.1	3.54	105	34
4	0.051	0.102	0.002	589.2	5.13	87	52
5	0.051	0.102	0.001	113	10	69	70

TABLE.2: Iteration dimensions of chassis by calculation

For optimization all above iterations was studied and the best solution of the chassis is mentioned as below:
Width of Chassis rectangular pipe = 51 mm
Height = 102 mm
Thickness of Rectangular pipe = 3 mm
And total length is kept constant as of Existing Chassis = 14 foot
Total Weight reduction of 34 Kg was achieved. The stresses on this system are in permissible limit.

C. Analysis existing and optimized chassis

i) Material: Material Properties are as follows
Density :7850 kg/cm^3
Modulus of elasticity : 2E+11 MPa
Ultimate Strength : 590 MPa
Poisson Ratio : 0.3

ii) Meshing:
In meshing medium type relevance centre is chosen and keeping the element size as 3 mm with uniform mesh. element type as tetrahedral element. Minimum edge length observed is 4.7914e-003 mm. Inflation taken as smooth transition. Number of nodes= 135003 and elements= 71411

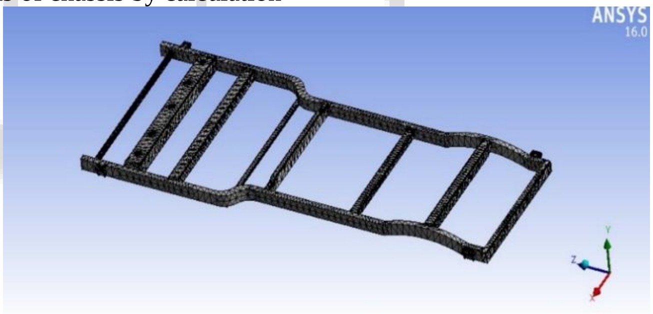

Figure 2: Meshing of Chassis

III. 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. These results as part of structural analysis are obtained for chassis.

A. Result of existing chassis:

After applying total load 2280 kg, uniformly distributed on roller, the deformation is shown in the following analysis results in various colour bands. Maximum stress is 187.07 M pa shown by red colour and minimum stress as 0.0031334 M pa and shown by blue colour.

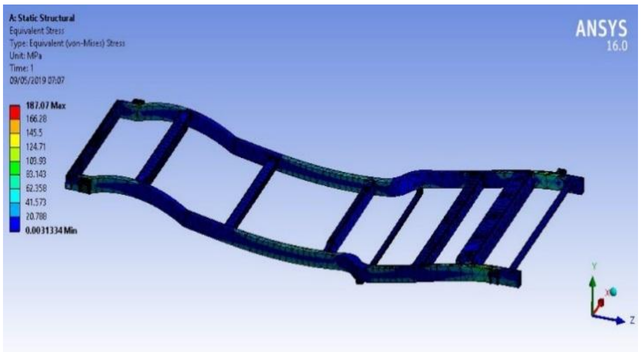

Figure 3: Von-Mises stress of existing chassis

After applying total load 2280 kg, uniformly distributed on Chassis, the deformation is shown in the following analysis results in various colour bands. The maximum deformation is shown in red band of 2.9413 mm and minimum deformation of 0.00 mm and shown by blue colour. As the chassis is long and the supports for the chassis is having the length between it as 2862 mm hence the deformation in the system is up to 2.9413 mm. if we compare this deformation with the length of chassis then the deformation is correct.

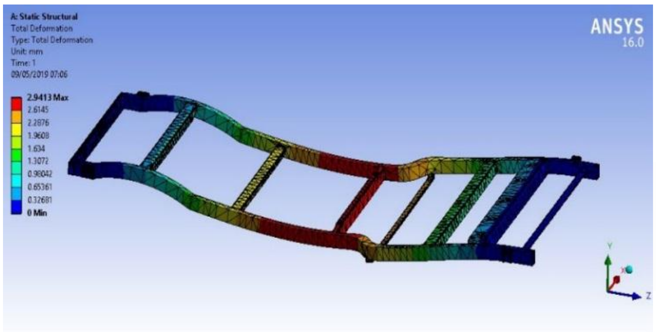

Figure 4: Total Deformation of existing chassis

B. Result of optimised chassis

After applying total load 2280 kg, uniformly distributed on roller, the deformation is shown in the following analysis results in various colour bands. Maximum stress is 312.18 M pa shown by red colour and minimum stress as 0.002921 M pa and shown by blue colour.

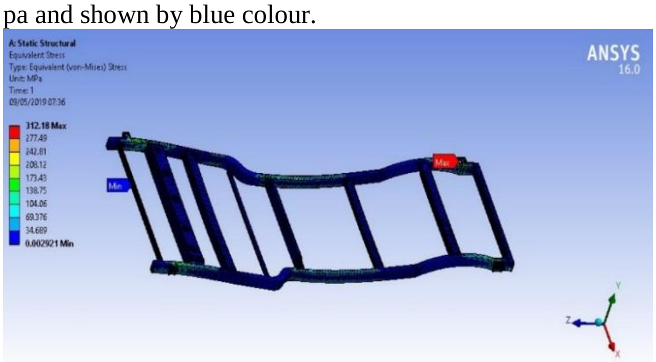

Figure 5: Von-Mises stress of optimised chassis

After applying total load 2280 kg, uniformly distributed on Chassis, the deformation is shown in the following analysis results in various colour bands. The maximum deformation is shown in red band of 2.6903 mm and minimum deformation of 0.00 mm and shown by blue colour. As the chassis is long and the supports for the chassis are having the length between it as 2862 mm hence the deformation in the system is up to 2.6 mm. If we compare this deformation with the length of chassis, the deformation is correct.

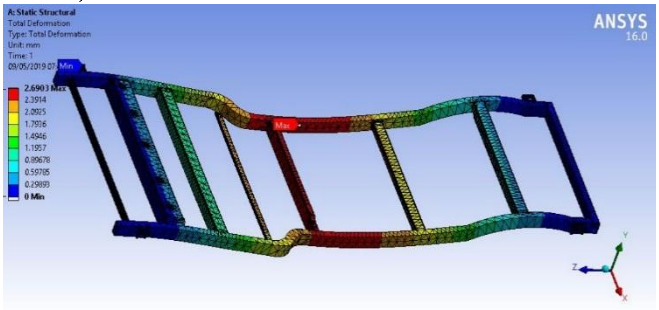

Figure 6: Total Deformation of optimised chassis

C. Experimentation

For experimentation purpose, we have reduced the length of the pipe to 5 foot for the suitable and feasible setup. After mounting the rectangular pipe on the universal testing machine as shown in images, load is applied which was increased gradually. Reaching the limit of 22.40 KN, the deflection of 1.00 mm is achieved. Because of the proportion of the reduction, we have achieved the deformation of 1.00 mm for the 5-foot pipe. If we calculate the deformation for the 14-foot pipe, it will be 2.8 mm.

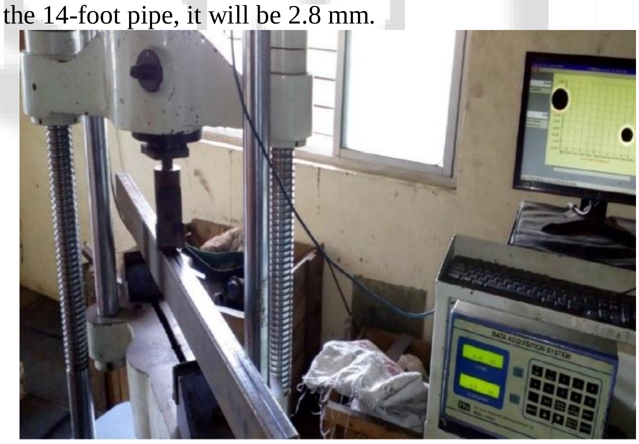

Figure 7: Experimental setup

D. Result Table

Comparisons of Results of rollers design calculations with ANSYS and experimental result.

Experiment was carried on a sample for checking deformation on UTM machine. As per the experimental setup, we have taken the reading. These results are shown in following table.

Dimensions	Design calculation results		Ansys results		Experimental results
	Deformation	Stress	Def.	Stress	Def.
B= 51 mm H= 102 mm T= 3 mm	3.3 mm	346 MPa	2.6 mm	312.18 MPa	2.8 mm

TABLE 3: Comparison of Ansys with experimental result

Weight of Existing	Weight of Optimised	% of Material used for	% of Material used for	% of Material saving

Chassis	System	existing system	Optimized system	
139 kg	105 kg	100 %	75.53 %	24.46 %

TABLE 4: Comparison of weight and material in existing with optimised system

The existing system is optimised in this project. The summary of optimisation is shown in above table. The weight of existing system is 139 Kg and weight of optimised system is 105 Kg. Thus, we achieved 34 Kg of weight reduction. Nearly 24.46 % of material was saved and thus the cost of the material also saved in the system.

IV. Conclusions

The existing chassis is having more weight. Optimized system is lighter in weight and is solution for disadvantages of existing system. Optimization was achieved by reducing the geometry of the system. Design calculations, analysis model, and experimental results of existing system and optimized system are compared on deformation and stress basis.

1) 34 Kg weight reduction is achieved by optimize design than existing design.
2) 24.46 % of material was saved on optimized system than existing system which further save cast of system.
3) Due to the weight reduction the fuel consumption of the vehicle will also reduce which is having again a positive advantage.
4) The weight reduction achieved on chassis does not affect the load carrying capacity of system.

V. Future Scope:

1) There is a high scope for further research in chassis simulation to solve vibration, frequency response and mode shape analysis related problems.
2) This chassis structure should be further analysed and improved on the overall performance especially on structural dynamic behaviour and quality auditing for better refinement.
3) Surface treatment on Chassis can be done for increasing strength of Chassis
4) Vibration analysis of whole system can be increase working capacity of system
5) Advance material science can be used for weight reduction. In this system by considering composite materials weight reduction may be achieved.

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