A Review on Design and static Analysis of Chassis Frame and properties of material used in Commercial Vehicle

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Abstract-In this paper, review is totally based on the few researches which are made in the past earlier years. In general automotive chassis is a skeleton part of the commercial vehicle which carries the component and different payload supported on it. In this review paper an effect is made to analyse the past few research papers based on chassis design and optimization and an attempt to review the different technique to analyse chassis and performed analysis on the properties of the material of chassis frame. There are a number of analytical methods and different techniques used to analyse the chassis. Commonly mild steel and structural steel is preferred for the manufacturing of the chassis but sometime alloy of aluminium, magnesium and carbon fibre are used to overcome the weight of the chassis. Most common thing in research papers is that analytical calculation is performed on the basis of different loading condition either static or dynamic and design 3D model in software like CATIA, CREO and SOLIDWORKS. Further meshing and simulations are performed in HYPERMESH and ANSYS. There are a lot of factors which are considering to design and optimise the chassis like stress analysis of the frame, material of the chassis, strength of frame, stiffness and weight. Through this review paper, observed that there is a gap in future scope to work on improvement of material's properties that make vehicle lighter and provide strength and implement new techniques to manufacture chassis frame to make it more reliable.

***Keywords*:** Chassis frame, FEA Analysis, ANSYS

1. Introduction

Automotive chassis is a skeletal part of the vehicle which carries various loads on it like engine, front suspension, rear suspension, transmission part, steering system and brakes which are bolted or welded on it. Chassis is considered as the most significant part of the vehicle that gives stability and strength to the vehicle. The chassis of the commercial vehicle considers long member with a number of cross members. Usually material which is used for the manufacturing of the chassis is alloy of steel but overcome the weight of chassis frame of the vehicle alloy of aluminium and magnesium is used in place of it. Automotive chassis also provides flexibility and strength to the chassis. Also on the behalf of the design frame should have strength to resist impact loading, twisting moment, vibrations and other different types of stresses like bending stress and shear stress. In today world the weight reduction is most concern topic in automobile industry but consider with optimization it is very important to take an account of safety factor. If any case of failure occurs in chassis then it may collapse the complete vehicle which is not easily be recovered. The design of the chassis is fundamental importance to improve overall performance of the vehicle. On the basis of loading condition and stress distribution different cross section of the chassis is used such as C section, I section and Rectangular section. Materials are used according to the requirement of equivalent stress of the various loading condition generally steel, magnesium and aluminium alloy are used for chassis manufacturing.

A. Ladder chassis : Resembles to its name, it is simplest and oldest design of chassis which consists of two long member or rails along the length of the vehicle and cross member to give structure and strength to the system.

B. Backbone Tube Chassis: It has a strong tabular backbone which is rectangular in cross section that connects front suspension and rear suspension area on which body was bolted.

C. Monocoque chassis: It is a French word which means single shell .It is similar to an egg shell whereby loads are supported by an object outer skin. It is a mono piece type structural chassis which is manufactured by welded floor and its part together. It manufacturing cost is very high because it is robotic based manufactured.

Functions of the chassis:

- To carry various parts like engine, transmission, brakes, suspension etc. on it.
- To carry payloads of goods carried on it.
- To withstand with the impact loads and sudden braking and accelerating action of the vehicles.

2.Literature review

Mohd Azizi Muhammad Nor, Helmi Rashid, Wan Mohd Faizul Wan Mohyiddin, Mohd Azuan Mohd Azian, Jamaluddin Mahmud, [1] carried out research to design, simulate and perform FE analysis of low ladder chassis frame which beam has I section on application of 35 ton gross vehicle load .Material used for the manufacturing of this trailer is a low alloy steel A710 C (class 3) of required yield strength 510 MPa and tensile strength is 620 MPa. In this research paper 3D model designed in CATIA and further simulation is performed in CATIA V5R18.By simulation maximum deflection and equivalent stress are determined and compared the data with the analytically calculated data with consideration factor of safety. The properties of raw material used for chassis manufacturing is described in table.1

Table.1 Material properties of low ladder chassis

Density(kg/mm^3)	7.8×10^6
Poisson ratio	0.29
Yield strength(Pa)	550×10^6
Tensile strength(Pa)	620×10^6
Modulus Elasticity	207×10^3 Mpa

By performing Finite Element Analysis revealed the value and location of maximum deflection and equivalent shear stress and compare the result with analytical solution consideration of factor of safety and modified design.

Mr Birajdar, M D and Prof Mule J Y, [2] this research was being done on the analysis and Design modification of ladder chassis frame of heavy commercial vehicle for Ashok Leyland model truck. In this research paper totally analytical calculation is performed, four different cross section was taken and vary the height of the chassis according to the constraints of bending stress, shear stress, deflection and equivalent stress. Reduction in area will reduce the overall contribution of materials and optimized the design of chassis frame. This research work is carried out on each long member of the chassis. In this research work four different cross section of chassis frame of four different vehicles which is C section, I section, hollow rectangular and intermediate

rectangular in cross section is used. After calculation of bending stress, shear stress, equivalent stress and deflection, through this research paper it is observe that strength of the intermediate rectangular chassis is greater than the C section, I section and hollow rectangular section chassis.

Kiran Ghodvinde and S R Wankhede, [3] works on the static analysis of monocoque chassis and ladder chassis respectively. In this dissertation work, first performed static analysis in kit car chassis with constrains of bending stress, shear stress and deflection .Kit car chassis is made up of 4130 Steel which outer diameter is 30 mm and thickness is 4 mm. The material properties is listed below

Table.2 properties of material

Modulus Elasticity (pa)	30×10^6
Density(kg/m^3)	7798
Yield strength(MPa)	435.059
Tensile strength(MPa)	670.17

In this research paper FE analysis of stress and deflection of the chassis is done in ANSYS software .Further analysis is performed on Chevy truck chassis which is designed in CATIA and simulation is performed in ANSYS. The cross section of this chassis is C section which carried gross vehicle weight is 4.5 ton and payload is 2500 kg.The material used for this chassis is AISI 4130 Alloy which properties are listed below:

Table.3 properties of alloy

Modulus Elasticity(psi)	29,733,000
Density (lb/cu.in.)	0.283
Poisson ratio	0.2816
Shear modulus	11,600,000
Specific gravity	7.8

In this research paper analysis of Kit car chassis under static condition, it is validate with cantilever beam and result shows that maximum stress is at the contact point of the beam while in case of Chevy truck chassis it was found that to reduce stress concentration at joint must be proper design and reinforce the joint to reduce chances of failure.

Anurag, Amrendra Kumar Singh, Akash Tripathi, Aditya Pratap Tiwari, Nitish Upadhyay and Shyam Bihari Lal, [4] has made research work and performed FE analysis on the truck chassis under static loading condition and generate result of maximum deflection and stress analysis result. The proposed model is being designed in CREO 3.0 and structural analysis is performed in ANSYS WORKBENCH 15.0 under static loading condition. This research work shows that the portions of the chassis where stress concentration is maximum due to static loading condition that being considered to be designed and optimized to reduce possibility of failure condition and improve its reliability. The material used in this research work is HSLA Steel.

Table.4 Material of truck chassis

Yield strength	310 Mpa
Modulus elasticity	2×10^6

R V Patil, P R Lande, Dr Y P Reddy, A V Sahasrabudhe, [5] this paper deals with the optimization of chassis of three wheeler by linear static analysis. This research work is studied the optimization of this chassis to attain reduced weight and cost by proper stress analysis. The material is used for this chassis is cold rolled steel IS 513 that have yield strength 250 Mpa. This chassis modelled is designed in Creo (Pro E) software and meshing done in Hypermesh 12.0 software. Further done simulation and plotting the graph of variation of displacement and stresss. Then compared the result with the existing design and get desired results of optimization. The material used for the chassis of this three wheeler given as

Table.5 Material of the chassis

Modulus Elasticity (Mpa)	210
Density(kg/mm^3)	7.8×10^6
Poisson ratio	0.29
Yield strength(Pa)	250×10^6
Tensile strength(Pa)	410×10^6

This paper shows that stress concentration is high at the front part of the chassis hence some reinforcement added these location to reduce stress level in spite of increasing thickness of whole chassis.

N K Ingole, D V Bhope [6] , have designed a four wheeler tractor trailer chassis that has gross vehicle weight is 8 ton, performed stress analysis to revealed the stress distribution and reduce the weight of the chassis with safer stress concentration at the location at which stress concentration is low on account of static loading condition. The model of the chassis of tractor trailer is designed in Pro E and gross vehicle weight is 9000 kg. FE analysis is performed in ANSYS and the material used for this chassis is structural steel, the properties of these chassis is shown in figure,

Table.6 Material properties

Modulus Elasticity (pa)	2×10^5
Density(kg/mm$^{3)}$	7.85×10^6
Poisson ratio	0.3
Yield strength(MPa)	250

Abhishek Sharma, Pramod Kumar, Abdul Jabbar [7], have worked on the optimisation of the TATA LPS 2515 EX chassis of heavy commercial vehicle which is designed in CATIA V4 parametric and performed FE analysis in ANSYS 15.0. There are three materials used for manufacturing of this chassis such as grey cast iron, AISI 4130 alloy steel, and ASTM 710 alloy steel. The conclusion of this paper is that AISI 4130 alloy steel is superior to other alloy steel and box shape cross section has less stress and deformation.

Teo Han Fui & Roslan Abd. Rahman [8] , have performed stress distribution analysis on the chassis of heavy weight vehicle that has gross vehicle weight is 4.5 ton and pay load 2.5 ton , cross section of the chassis is C section that has five cross member and two rails. The material used for this chassis is AISI 4130 alloy with tempered and quenched treatment. The conclusion came that the maximum stress at the bracket of the suspension system and translation maximum where symmetry and asymmetry load is acting.

3. Conclusion

In this research paper, it is studied many of the research paper on chassis design and concluded as

- Most of the researchers performed FE Analysis using ANSYS, CATIA software while few one also used NASTRAN, HYPERMESH and ABAQUS.
- It is noticed that along with conventional material like mild steel and structural steel also alloy of aluminium, magnesium and carbon fibre are studied.
- After careful studies of researches it has been found that chassis of the vehicle validated by either by cantilever beam or simply supported beam under static loading condition.
- To enhance the life of the chassis, the property of the material should be improved and performed analysis under static and dynamic loading condition.
- To fulfil the gap, future scope of this chassis is focused to improve material property and manufacturing technique such as Hydroforming etc. to make its more reliable.

4. References

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