Design Modification for Weight Reduction and Structural Analysis of Eicher 11.10 Automotive Chassis Frame

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Abstract - *Automotive chassis is an important part of an Automobile. The chassis serves as a frame work for supporting the body and different parts of the automobile. Also, it should be rigid enough to withstand the shock, twist, vibration and other stresses. We describe the design of chassis and implementation of our design. A structural analysis of chassis frame has been done. The proposed work has been implemented on the Eicher 11.10 model by considering its 'C' section.*

Key Words: chassis, design, weight optimization

1. INTRODUCTION

The dump truck used for transporting loose materials in mining and construction. A typical dump truck is equipped with a hydraulically – operated suspension with closed box structure chassis, a body which is located at the top of the chassis. The chassis supported at the front and rear side suspension of the truck. The purpose of the body is lifted rear side of the vehicle, which is to deposit the materials on the ground. Chassis is an important part of the load carrying member of a rear dump truck over which the entire equipment is structured. Chassis acting as a structural support for power train elements and also enables the dump body carrying full payload. The chassis is neither a serviceable nor a replaceable component as far as the life span of the vehicle is concerned. The life span of a chassis must be equal to or more than 30,000 running hours under normal operating condition of the vehicle.

To increase the fatigue life and its propagation across the chassis and to avoid crack, it is absolutely necessary to have an optional design to withstand the complete load under normal conditions. For this purpose, it is necessary to strengthen the frame and to increase the safety factor of the chassis for an increased fatigue life.

2. LITERATURE REVIEW

Dave Anderson studies involved representing the distributed mass and elasticity of the vehicle structures e.g. frame ladder, the non-linear behavior of shock absorbers, reproduce the fundamental system dynamics that influence ride and provide output of the acceleration, velocity and displacement measures needed to compute ride quality. There were three main factors contributed in this study. Firstly, the author had come out with the development of an ADAMS multi-body dynamics model for use as a predictive tool in evaluating ride quality design improvement. The model includes frame, cab and model generated from finite element component mode synthesis [1].

I.M. Ibrahim analyze the vehicle dynamic responses to external factors. The spectral analysis technique was used in the problem study. Other than that, the driver acceleration response has been weighted according to the ISO ride comfort techniques. From the author point of view, the excessive levels of vibration in commercial vehicles were due to excitation from the road irregularities which led to ride discomfort, ride safety problems, road holding problems and to cargo damage or destruction. Also, it has been found that the frame structure vibrations due to flexibility have a similar deleterious effect on the vehicle dynamic behavior [2].

William B. Riley taken from work completed by the first author as a member of the 1999 Cornell University Formula SAE Team and discusses several of the concepts and methods of frame design, with an emphasis on their applicability to FSAE cars. The paper introduces several of the key concepts of frame design both analytical and experimental. The different loading conditions and requirements of the vehicle frame are first discussed focusing on road inputs and load paths within the structure [3].

N. Lenin Rakesh has studies the present scenario in automotive industry is an sum in demand of trucks not only on the cost and heaviness aspects but too on improved total vehicle features and overall work performance. The chassis plays an important role in the design of any truck. Truck chassis forms the structural backbone of a commercial vehicle. The main function of the truck chassis is to support the components and payload placed upon it. When the truck travels along the road, the chassis is subjected to vibration induced by road roughness and excitation by vibrating components mounted on it. The responses of the truck chassis which include the stress distribution and displacement under various loading condition are also observed [4].

S. A. Karthikeyan investigated that the truck chassis is a major component in a vehicle system. This work involves static and dynamics analysis to determine the key characteristics of a truck chassis. The static characteristics

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include identifying location of high stress area and determining the torsion stiffness of the chassis. The dynamic characteristics of truck chassis such as the natural frequency and mode shape were determined by using finite element (FE) method. Experimental modal analysis was carried out to validate the FE models. The overall modifications resulted in the natural frequency shifted by 13 % higher than the original value, increased the torsion stiffness by 25 % and reduced the total deflection by 16 %. The overall weight of the new truck chassis was increased by 7% [5].

Abhishek Singh carried out analysis on Hyper Mesh we have concluded that our Rectangular Box (intermediate)section is safer under 12.825 tone load which is the Total weight of vehicle including gross vehicle weight and weight of passengers. The displacement is good of our Rectangular Box (intermediate) section in comparison to C, I and Rectangular Box (hollow) section type chassis therefore our chassis is more safer among all type of cross sections [6].

A.Hari Kumar observed that the Rectangular Box section is having more strength than C and I Cross-section type of Ladder Chassis. The Rectangular Box Cross-section Ladder Chassis is having least deflection i.e., 2.96 mm and least Von Mises stress and Maximum Shear stress i.e., 54.31MPa & 5.98MPa respectively for Aluminum Alloy 6063-T6 in all the three types of chassis of different cross section. Finite element analysis is effectively utilized for addressing the conceptualization and formulation for the design stages [7].

Chintada Vinnod babu studied that the static structural analysis of the truck chassis in which study of the stresses developed and deformation of chassis frame of EICHER 11.10 has been done by considering three different materials like St52, Ni-Cr Steel and CFRP in each case. The chassis is modeled in PRO-E and finite element analysis has been done in ANSYS [8].

3. METHODOLOGY

Step I: To analyze & optimize the frame.

Step II: To machine the optimize material.

Step III: To define a material & property.

Step IV: To apply topology optimization & take results of stress, strain plots, compare the results & conclude.

4. FE ANALYSIS OF CHASSIS

A. Modeling of Chassis

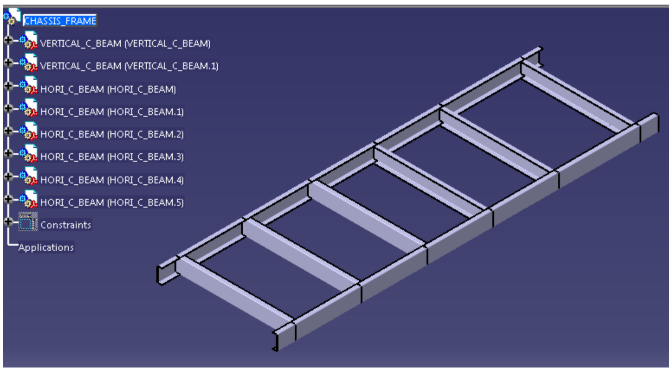


Fig.No.1 CAD Model of Chassis

a. Mesh Generation

Finite Element Method (FEM)

It is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It is also referred to as finite element analysis (FEA). FEM subdivides a large problem into smaller, simpler, parts, called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function.

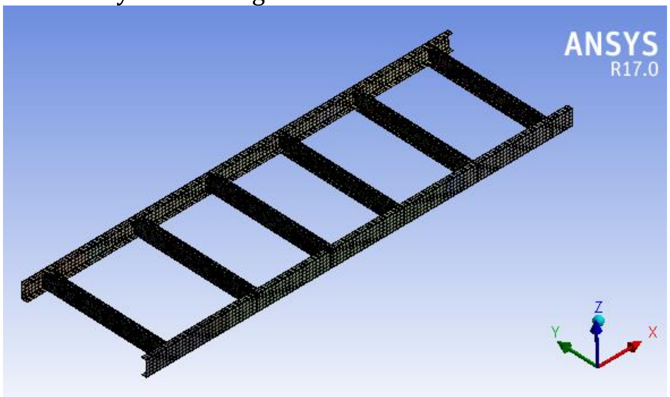


Fig.No.2 Discretized Model

Element type-Hexahedron, Tetrahedron
No. of Elements-22546
No. of Nodes-64475

b.Basic Calculation for Chassis Frame:

Model No. = 11.10 (Eicher E2)
Side bar of the chassis are made from "C" Channels with 245mm x 76mm x 5mm
Front Overhang (a) = 935 mm
Rear Overhang (c) = 1620 mm
Wheel Base (b) = 3800 mm
Radius of Gyration R =245/2 =122.5 mm
Capacity of Truck = 8 ton

= 8000 kg
= 78480 N
Capacity of Truck with 1.25% = 98100 N
Weight of the body and engine = 2 ton
= 2000 kg
= 19620 N
Total load acting on chassis = Capacity of the Chassis + Weight of body and engine
= 98100 + 19620
= 117720 N
Chassis has two beams. So load acting on each beam is half of the Total load acting on the chassis.
Load acting on the single frame = 117720/2
= 58860 N / Beam

B.Static Structural Analysis

a.FEA Pre Processing

The pre-processing of the chassis is down for the purpose of the dividing the problem into nodes and elements, developing equation for an element, applying boundary conditions, initial conditions and for applying loads. The information required for the pre-processing stage of the chassis is as follows:
Material properties: The values of young's modulus, poisons ratio, density, and yield strength for chassis are taken from material library of the FEA PACKAGE.

Material- Steel

Young's Modulus- 200 GPa

Poisons Ratio- 0.3

Density- 7850kg/m^3

Yield Strength- 520 MPa

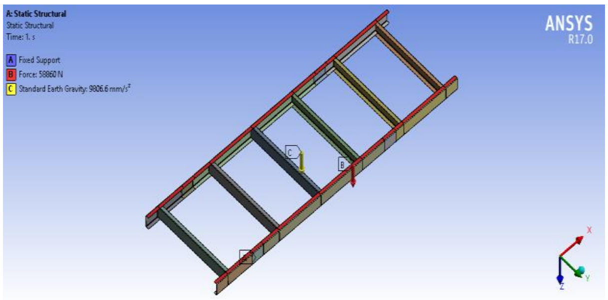


Fig no.3 Boundary Condition

b.Post Processing

The acceptability of the design of the chassis needs to be considered from the results of the analysis. The guidance for the modification of the chassis needs to be available if the design is not considered to be acceptable for the chassis is as follows.

Model acceptance criteria: the maximum Von-Mises stress must be less than the material yield strength for the duration of the component. The deflection is considered and the maximum Von-Mises stress must be less than the yield strength for above load case.

c.Von- Mises:

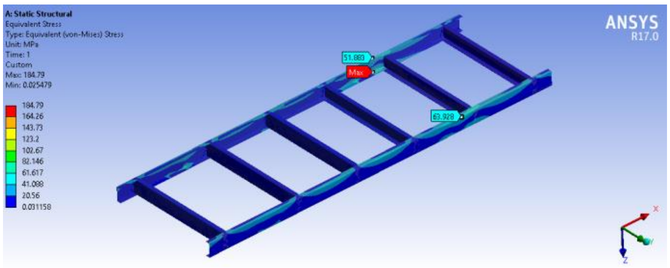


Fig.no.4 Von- Mises stress of chassis

d.Deformation

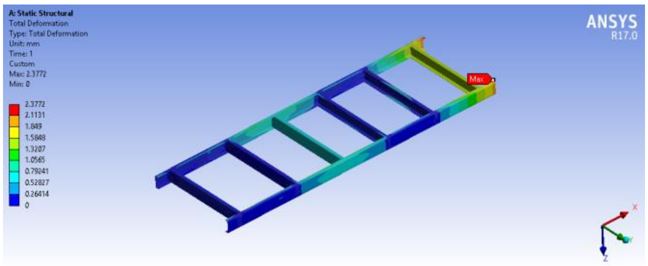


Fig.no.5 Deformation of chassis

Maximum Deformation is 2.377 mm

e.Pre- Stress Modal Analysis of Chassis:

Results:

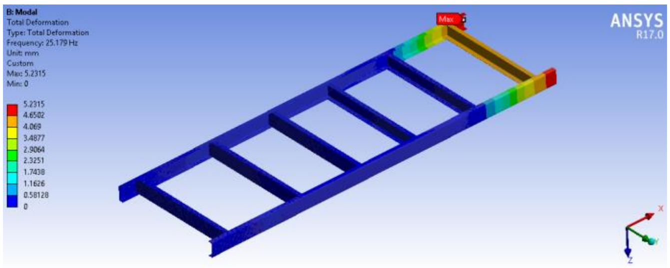


Fig.no.6 Mode-01

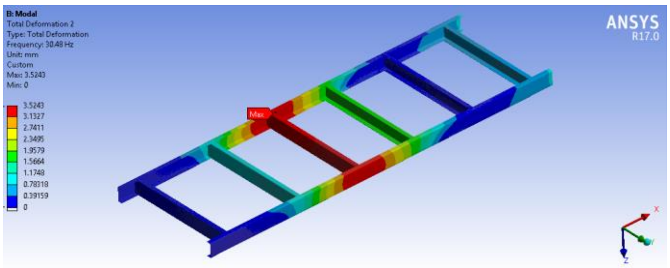


Fig.no.7 Mode-02

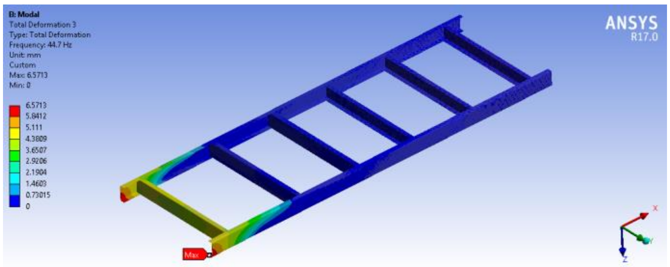
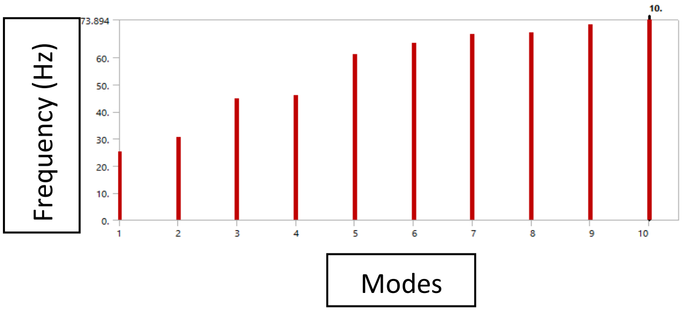


Fig.no.8 Mode-03



Graph 1

TABLE I

Tabular data

Tabular Data

	Mode	Frequency [Hz]
1	1.	25.179
2	2.	30.48
3	3.	44.7
4	4.	45.938
5	5.	61.255
6	6.	65.344
7	7.	68.44
8	8.	69.225
9	9.	72.056
10	10.	73.894

B.Harmonic Analysis of Chassis:

Boundary Condition:

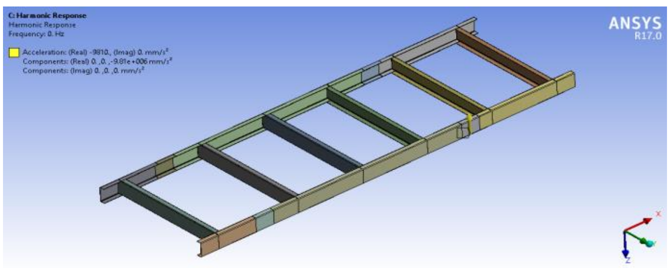


Fig.no.9 Boundary Condition for Harmonic Analysis of Chassis

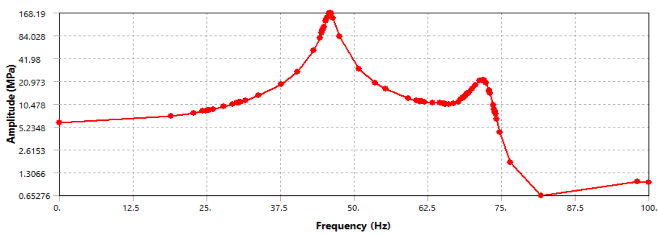
TABLE II

Boundary Condition Setting

Details of "Acceleration"

Scope	
Boundary Condition	Fixed Support
Definition	
Base Excitation	Yes
Absolute Result	Yes
Define By	Magnitude - Phase
Magnitude	-9810. mm/s²
Phase Angle	0. °
Direction	Z Axis
Suppressed	No

Result:



Graph 2

Frequency Response

TABLE III

Frequency Response Result

Results	
Maximum Amplitude	168.19 MPa
Frequency	45.919 Hz
Phase Angle	90.698 °
Real	-2.05 MPa
Imaginary	168.18 MPa

5. CONCLUSION

software for further analysis of finite element analysis. Then, the result from both analysis will then be compared and the virtual structural model will be developed using FEM tools. In this stage, the finite element and experimental torsion analysis will also be performed. The objective of these tests is to find the torsion stiffness of the structure and the response of the applied load at different loading condition. The next steps are the correlation and model updating process to obtain the virtual structure of the chassis. Then, the final stage is the modification of the virtual model to find the optimum chassis condition and suited with current market demand. The final result of the modification of finite element analysis is then proposed for future actual modification.

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