p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 14
October 2016

Design and Structural Analysis of Heavy-Duty Chassis

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ABSTRACT

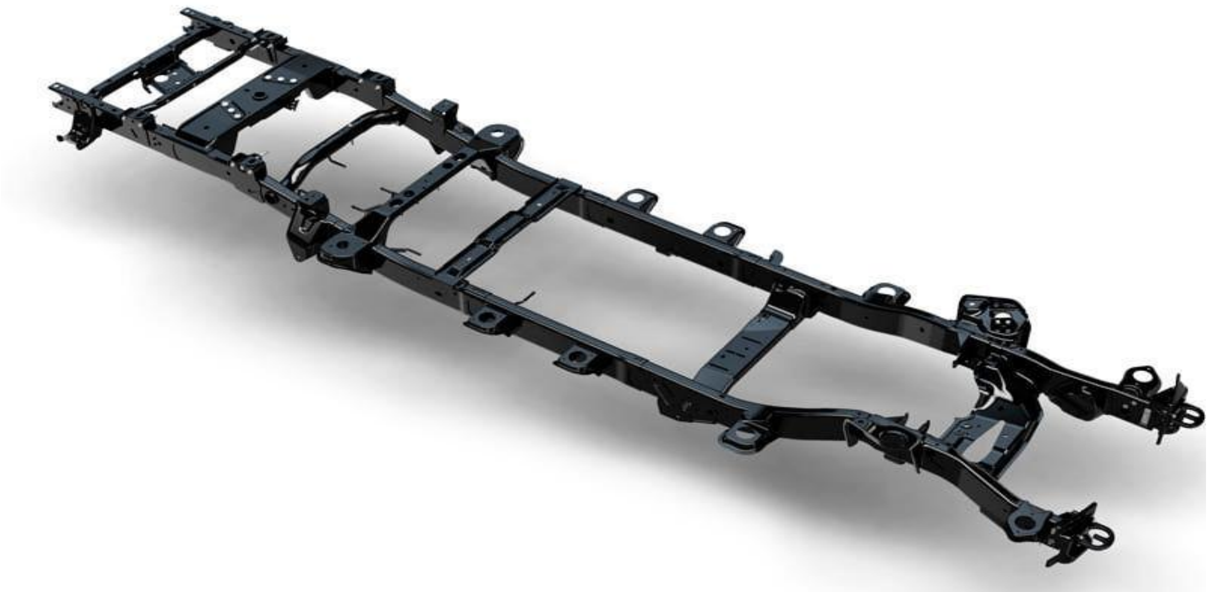
A frame is the main structure of the chassis of a motor vehicle. All other components fasten to it; a term for this design is body-on-frame construction. A chassis consists of an internal framework that supports a man-made object in its construction and use. It is analogous to an animal's skeleton.

The main objective of the project is how to develop the prototype of Heavy Duty Chassis with two different types of sections (C & I)of heavy-duty vehicle using CAD tool CREO 2.0.These assembly consists major components they are main frame (stiffeners, longerons) with required dimensions. .

And importing the components which are developed in CAD tool into CAE tool ANSYS for to analyze. To find out the deformations and stress efficiency of the components Appling the existing material (Mild-Steel) and chosen material (composite material-Epoxy & S2 glass). To showing the comparison between two materials for components when the compressible loads are different.

INTRODUCTION

CHASSIS: - A chassis consists of an internal framework that supports a man-made object in its construction and use. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted). If the running gear such as wheels and transmission, and sometimes even the driver's seat, are included then the assembly is described as a rolling chassis.



A frame is the main structure of the chassis of a motor vehicle. All other components fasten to it; a term for this design is body-on-frame construction.

In the case of vehicles, the term rolling chassis means the frame plus the "running gear" like engine, transmission, drive shaft, differential, and suspension.

An under body (sometimes referred to as "coachwork"), which is usually not necessary for integrity of the structure, is built on the chassis to complete the vehicle.

For commercial vehicles, a rolling chassis consists of an assembly of all the essential parts of a truck (without the body) to be ready for operation on the road. The design of a pleasure car chassis will be different than one for commercial vehicles because of the heavier loads and constant work use. Commercial vehicle manufacturers sell "chassis only", "cowl and chassis", as well as "chassis cab" versions that can be outfitted with specialized bodies. These include motor homes, fire engines, ambulances, box trucks, etc.

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In particular applications, such as school buses, a government agency like National Highway Traffic Safety Administration (NHTSA) in the U.S. defines the design standards of chassis and body conversions.

An armoured fighting vehicle's hull serves as the chassis and comprises the bottom part of the AFV that includes the tracks, engine, driver's seat, and crew compartment. This describes the lower hull, although common usage might include the upper hull to mean the AFV without the turret. The hull serves as a basis for platforms on tanks, armoured personnel carriers, combat engineering vehicles, etc

In an electronic device, the chassis consists of a frame or other internal supporting structure on which the circuit boards and other electronics are mounted. In the absence of a metal frame, the chassis refers to the circuit boards and components themselves, not the physical structure. In some designs, such as older sets, the chassis is mounted inside a heavy, rigid cabinet, while in other designs such as modern computer cases, lightweight covers or panels are attached to the chassis.

The combination of chassis and outer covering is sometimes called an enclosure.

The main functions of a frame in motor vehicles are: -

FUNCTION: -

1. To support the vehicle's chassis components and body
2. To deal with static and dynamic loads, without undue deflection or distortion.

   These include:

   - Weight of the body, passengers, and cargo loads.
   - Vertical and torsional twisting transmitted by going over uneven surfaces.
   - Transverse lateral forces caused by road conditions, side wind, and steering the vehicle.

- Torque from the engine and transmission.
- Longitudinal tensile forces from starting and acceleration, as well as compression from braking.
- Sudden impacts from collisions.

There are three main designs for frame rails. Normally the material of construction for chassis and along with frame is carbon steel alloys or aluminium Alloys (Light Weight frames). Their cross-sections include:

1. C-shaped

2. Boxed

3. Hat

TRUCK: -

A truck is a motor vehicle designed to transport cargo. Trucks vary greatly in size, power, and configuration, with the smallest being mechanically similar to an automobile.

Almost all trucks share a common construction: they are made of a CHASSIS, a cab, an area for placing cargo,
equipment, axles, suspension and road wheels, an engine and a drive train. Pneumatic, hydraulic, water,
and electrical systems may also be present. Many also tow one or more trailers or semi-trailers.

TYPES OF TRUCKS: -

The three main classifications for road truck by weight are light trucks, medium trucks, and heavy trucks. Above this there are specialised very heavy trucks and transporters such as heavy haulers for moving oversized loads, and off-road heavy trucks used in and mining which are too large for highway use without escorts and special permits.

HEAVY TRUCKS: -

Except for semi-trailer trucks and, generally, mobile cranes, the following types may also come in medium sizes.

In Heavy trucks: -

Tatra is a vehicle manufacturer in Kopřivnice, Czech Republic. The company was founded in 1850 as Schustala & Company, later renamed Nesselsdorfer Wagenbau-Fabriksgesellschaft when it became a

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e-ISSN: 2348-795X
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wagon and carriage manufacturer. Tatra is the third oldest car maker in the world after Daimler and Peugeot. During World War II Tatra was instrumental in the production of trucks, and tank engines for the German war effort.

Tatra produces a range of primarily all-wheel-drive 4×4, 6×6, 8×8, 10×10, and 12×12 trucks.

LITERATURE REVIEW

Hoffmeyer et al. in 2006 [1] discussed some issues in multi axial fatigue and life estimation is presented. While not intended to be comprehensive, these are a relatively broad range of issues which are commonly encountered when dealing with multi axial fatigue. They include damage mechanisms, non-proportional hardening and constitutive behavior, damage parameters and life estimation, variable amplitude loading, cycle counting, damage accumulation, and mixed-mode crack growth. Some simple approximations in capturing some of these effects in multi axial life estimations are also presented. In 2007, Ye and Moan [2] discussed static and fatigue behavior of three types of aluminum boxstiffener/web connections are investigated in this study. The main purposes are to provide a connection solution that can reduce the fabrication costs by changing the cutting shapes on the web frame and correspondingly the weld process and meanwhile sufficient fatigue strength can be achieved. Finite element analyses (FEA) show the influence of local geometry and weld parameters on the stress gradient near the fatigue cracking area. The influence of the weld parameters on the structural stress concentration factors is also studied. Twelve specimens of every type were tested and the test data are compared both to a nominal stress based design SN curve Eurocode9/31 and a structural stress based design SN curve Eurocode9/44. RoslanAbd Rahman et al. [3] conducted stress analysis of heavy duty truck chassis by utilizing a commercial finite element package ABAQUS. To determine critical point so that by design modifications the stresses can be reduces to improve the fatigue life of components. During this he uses ASTM low alloy steel a 710 C (Class 3) with 552 MPa of yield strength and 620 MPa of tensile strength for chassis founds the maximum stress 386.9 MPa at critical point occurred at opening of chassis This critical point is located at element 86104 and node 16045, which is in contacted with the bolt from this he concludes that this critical point is an initial to probable failure. Kurdi et al. in 2008, [4] discussed about the one of the most important steps in development of a new truck chassis is the prediction of fatigue life span and durability loading of the chassis frame. The age of many truck chassis in Malaysia are of more than 20 years and there is always a question arising whether the chassis is still safe to use. Thus, fatigue study and life prediction on the chassis is necessary in order to verify the safety of this chassis during its operation. Stress analysis using Finite Element Method (FEM) can be used to locate the critical point which has the highest stress. Critical point is one of the factors that may cause the fatigue failure. The magnitude of the stress can used to predict the life span of the truck chassis. The stress analysis is accomplished using the commercial finite element packaged ABAQUS by Veloso et al. [5]. They discussed the failure investigation and stress analysis of a longitudinal stringer of an automobile chassis Fiat Automóveis, Rod. Fernão Dias, km 429, Betim, MG, Brazil Pontifical Catholic University of Minas Gerais (PUC Minas), Mechanical Engineering, Belo Horizonte, MG, Brazil A prototype vehicle was submitted to durability test, on road at a proving ground test track. Failures of posterior longitudinal stringers were observed during this test. Cracks were nucleated on these stringers during durability test, before the designed life of these components is reached. These cracks were observed at nearly the bumpers fixation points of the vehicle suspension. Loads are transmitted by wheels to the body of the vehicle through the suspension components. Thus, the longitudinal stringers are subjected to these localized cyclic stresses. Also, Palma et al. in2009 [6] investigated to analyze the fatigue behavior of an automobile body part, according to the standards of performance. The methodology is based on experiments performed on a rear trailer tow hook pin of a passenger automobile vehicle. Experiments were performed simulating the actual conditions in the customer environment. Stress and strain were experimentally measured by using strain gages, bonded on assembly critical points. Besides, stress analysis was also performed using a finite element program. Fatigue analysis is used to access and to compare the fatigue damage imposed during laboratory experiments. Recently in 2011, Chen and Zhu [7] studied the YJ3128-type dump truck‟s sub-frames, for the fatigue crack occurred in the Sub-frame which has worked in bad condition for 3 to 5 months. The sub-frame was analyzed by ANSYS and the reason for the cracking of the frame was found according to the different stress. At last an improvement and optimization to the structures of the frame was provided. Also Hengji et al. in 2012 [8] explained the fatigue life for frame of the 220t mining dump truck, a fatigue life analysis method was presented by integrating multi body dynamic analysis and finite element method. The forces of main joints at frame were measured from the multi body dynamic model, whose road was restructured. The dynamic stress test of the whole truck was implemented to obtain the peak stress of the mainly forced area, which was compared with the simulated stress. It was found out that the error was allowable so that the accuracy of the finite element model was definitely ensured. The quasi-static stress analysis method was employed to acquire stress influence coefficient under unit load, which was associated with load histories of the frame to get the dangerous stress area. The fatigue life of the frame was calculated on the basis of Palmgren–Miner damage theory. It was turned out that the minimum life area of the frame is located at the frame joints of suspension, which matches the practice. More recently, Bhat et al. in 2014 [9], redesigned a modified chassis for tractor trolley. The existing trolley chassis designed by industry uses „C" Cross section having dimension 200mm x 75mm x 7mm and the material used was mild steel. By keeping the material and dimension similar and using „I" cross section area instead of „C" resulted in more safer stresses than „C" and 31.79kg reduction in weight. They concluded that the Reduction in weight shows that raw material required for manufacturing of the Chassis was reduced. Also, they obtained safer stresses in new suggested design and increase in factor of safety obtained in new suggested design

RESULTS AND DISCUSSION

Side bar of the chassis are made from "C" Channels with200mm x50mm x25 mm Front Overhang (a) = 740 mm Rear Overhang (c) = 1400 mm Wheel Base (b) = 6670 mm Material of the chassis is St 52 E = 2.10 x 105 N / mm2 Total load acting on chassis = Capacity of the Chassis + Weight of body and engine= (25000+600+400+200)*9.81 = 257022N Chassis has two beams.

So load acting on each beam is half of the Load acting on the single frame = 357022 / 2 = 1285110 N / Beam Chassis is simply clamp with Shock Absorber and Leaf Spring. So Chassis is a Simply Supported Beam with uniformly distributed load. Load acting on Entire span of the beam is 128511 Length of the Beam is 8810 mm. Uniformly Distributed Load is 1285110/ 8810 =114.58 N/mm

Safety factor= yield stress/ working stress = 250/114.58=2.19 the safety factor is greater than 1 so object is safe.

Side bar of the chassis are made from "I" Channels with150mm x50mm x20 mm Front Overhang (a) = 740 mm Rear Overhang (c) = 1400 mm Wheel Base (b) = 6670 mm Material of the chassis is St 52 E = 2.10 x 105 N / mm2 Total load acting on chassis = Capacity of the Chassis + Weight of body and engine= (25000+600+400+200)*9.81 = 307022N Chassis has two beams.

So load acting on each beam is half of the Load acting on the single frame = 307022 / 2 = 1585110 N / Beam Chassis is simply clamp with Shock Absorber and Leaf Spring. So Chassis is a Simply Supported Beam with uniformly distributed load. Load acting on Entire span of the beam is 128511 Length of the Beam is 8810 mm. Uniformly Distributed Load is 1585110/ 8810 =155.98 N/mm

Safety factor= yield stress/ working stress = 500/155.98=3.22 the safety factor is greater than 1 so object is safe.

CONCLUSION

In This Project Heavy Duty Chassis 3D model is done by using Pro-E with different cross sections with dimensions. And analysis is done by using ANSYS. In analysis part the chosen materials are M-S & Composite Material (Epoxy-S2 Glass) are applied to chassis in Ansys.

In this project we applied two different boundary conditions for both chassis. For c-section chassis we applied only 10e5N and for i-section chassis we applied 30e5N and calculating results like deformation, stress, safety factor values. For this we got maximum stress values 117.59 Mpa for c-section and 172.59Mpa for i-section chassis but both chassis were safe at this stress. In this case we got same stress values for 2 materials. And the strength is very high for epoxy s2 glass.

Finally we can conclude here the both chassis cross sections were safe at their respective boundary conditions but when we compare both chassis the i-section has nearly 5 times stronger than c-section with mild steel.

RESULT: -

M-S: - > Receiving less deformation comparing with Composite Material.

> Low cost comparing with Composite.

> Available at everywhere.

Epoxy & S2 glass.: -> Receiving high deformation comparing with M-S.

> Highly Expensive comparing with M-S.

> Available at Rare

Composite Material (Epoxy & S2 Glass) is Expensive Comparing with M-S Material.

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