# Analysis and Optimization of Truck Chasis

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***Abstract*:- In the contemporary world, the vehicle stability, handling and ride comfort are the major areas of concern in designing an automotive chassis. Various improvements can be done by analyzing the design factors thoroughly. Maximum deflection under loading conditions and the dynamic properties under vibrational excitation are the design factors for a pick-up truck chassis considered in this work. Three- dimension solid model of a pick-up truck chassis with a gross vehicle weight of 4 tons was designed in CATIA software. Finite element analysis of the pick-up truck chassis was carried out using ANSYS and its static behavior was studied taking four different types of material. It was observed that the most suitable material was found out to be HSLA Steel with a maximum deformation of 0.74988 mm. Dynamic properties were investigated using modal and harmonic analysis using the FEA software. The responses of the chassis under frequency distribution were observed and the design was found to be safe.**

***Keywords: Pick-up Truck Chassis; CATIA; ANSYS; Static Analysis; Modal Analysis; Harmonic Analysis; CAE.***

## INTRODUCTION:

An automobile is made up of mainly two units- The body and the Chassis. A vehicle arrangement without body is called chassis. The various components and systems of the chassis are the power unit, power train and the running system. Chassis is the French term usually to denote the main structure of a vehicle. In the vehicle construction chassis is the basic requirement. It is the main mounting of all the components including the body. it is also called carrying unit. The power unit contains only the engine; transmission includes clutch, propeller shaft with universal joints, differential and the real axle shafts; systems consist of brakes, wheels, tires, frame, suspension and the steering system. Cross bracings are provided in the chassis to withstand the shock, blows, twists and vibrations. As per the layout, the engine is mounted on the front part of the frame. Rubber cushioned mounts or pads are used to support the engine on the frame.

The clutch is placed, next to the engine, connected to the flywheel; Transmission or the gear box is positioned or attached to the clutch shaft. Then a propeller shaft is laid to connect the gear box on one end and the final drive on the other end. These are enclosed in a housing, bolted to the rear axle spring, which is connected to the frame through springs. The entire arrangement mounted and bolted on the chassis frame is supported by the front and rear suspension systems. This is positioned over front and rear wheel and tire assemblies, to avoid or minimize the transmission of shock to the frame.

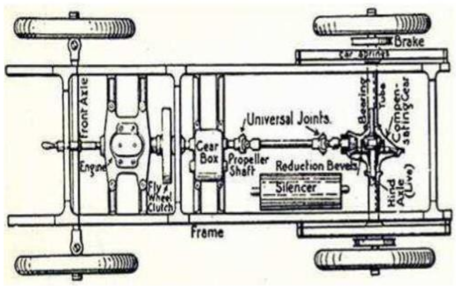


Fig: Layout of chassis

*Requirement of Chassis:*

1. To be strong with good strength to hold the components in position during running and driving.
2. To support the total weight of the vehicle inclusive of cargo and passengers.
3. To resist bending, twisting and torsional stresses.
4. To pull the heavy objects, trailer along with, either directly or indirectly.

## CRASH INDRODUCTION:

In automobile design, crash and structural analysis are the two most important engineering processes in developing a high quality vehicle. Computer simulation technologies have greatly enhanced the safety, reliability, and comfort, environmental and manufacturing efficiency of today's automobiles. This significant achievement was realized with the advanced software and powerful computers that have been available in the last twenty years. The primary concern for drivers and passengers is safety. Governments have responded to this key concern and expectation with an in creasing number of regulations. Al thought he details may vary slightly from country to country, the fundamental requirements are almost similar. A vehicle is expected to provide adequate protection to drivers and passengers in a not so serious accident. To protect the occupants of a car, there are many new tangible safety features such as airbags; ABS control brakes, traction control. A less tangible feature that cannot easily be seen by drivers and passengers is the crash response behavior. In a well designed automobile, the car body and various components are the protective layer for the occupants of the vehicle. They serve as the crumpling zone to absorb the energy of impact. The traditional approach involves multiple iterations of design, prototype and crash tests. The process is time consuming and expensive. The availability of high performance computers and crash simulation software has revolutionized the process. Instead of relying on experimental validations, the safety design process is supplemented with computer simulation to evaluate the design. Since the inception of crash simulation, the product cycle of a new automobile has been reduced by half and the resultant vehicle is safer, better and more comfortable.

CRASH SIMULATION EVALUATION:

| Year | Regulatory requirements | FE Model size (elem) | Prototype Required cars |
|---|---|---|---|
| 1990 | 1 | 10000 | 150 |
| 1995 | 3 | 20000 | 120 |
| 2000 | 5 | 80000 | 100 |
| 2005 | 15 | 0.5M | 70 |
| 2010 | 20 | 1M | 50 |
| 2017 | 30 | 1.5M | 20 |

MODELLING OF CHASSIS:

A pickup truck- 2015 Chevrolet Silverado was taken for modelling. It was a huge assembly, which had many sub-assemblies like powertrain assembly, chassis assembly, etc. For this project only the chassis was required, so all other assemblies were deleted.

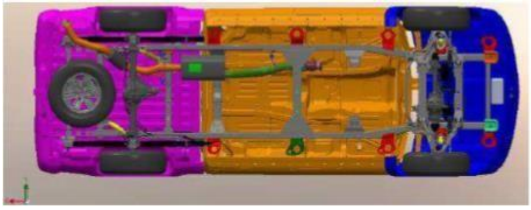

Fig:bottom view of Chevrolet Silverado

The chassis sub assembly consisted of 171 parts. Many parts in the chassis like nuts, bolts, name plate, etc were, not considered as these parts do not add any significance to the study here. These parts do not contain any loads or any constraints. The neglecting of these parts reduces the complexity in the chassis structure and also decreases the total simulation time. Some of the neglecting parts are shown below. After neglecting the redundant parts, the thickness of all the remaining parts was measured and noted. The assembly was saved as a .step file format to be imported in Ansys workbench for crash analysis. These parts were all thin structures, i.e. the third dimension was very small compared to the other two dimensions.

MESH GENERATION OF THE CHASSIS:

The component in Solidworks is an entity which contains the geometry and the mesh for a particular part. Every component is linked to a material and a property. All the parts in the chassis assembly were thin structures. It is not advisable to mesh these parts with 3D elements because if we do so, we would need at least 3 to 4 elements across the thickness. This will increase the total number of elements, which in turn increases the simulation time drastically. For this reason, the decision to perform the 2D meshing for the chassis was taken. Whenever 2D mesh is done, Solidworks creates shell elements on the surface. Shell elements have no visual thickness representation. The user assigns a thickness to the shell elements. The software assigns this thickness symmetrically to the mesh, assuming that the mesh is at the mid plane of the component. After creating the mid- surfaces, a geometry cleanup was performed where any discrepancies in the Solidworks was corrected. Once the surfaces were checked, the 2D mesh was generated. Solidworks 2D Automesh option was used. In Automesh the user can select the surfaces to mesh and provide a target element size & type and the software meshes the part. There are two types of 2D shell elements in Solidworks, trias (3 node triangle element) and quads (4 node quadrilateral elements). All the surfaces are meshed with both types of elements. All the elements were first order elements. After meshing, all the components had to be connected. In reality all the parts in the chassis are mated together. A similar thing was performed in FEA where all the components are connected together by mate connections. Solidworks has a connector option, where the user can connect parts by mate. The nodes of the edge of a part are selected, and the parts to be mate are selected.

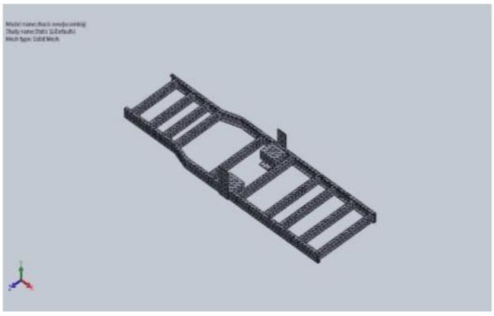

Fig:Meshed Modelled Of Channel section chasis

*Crash Analysis:*

A crash test is a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for various modes of transportation or related systems and components.

- **Frontal-impact tests**: which is what most people initially think of when asked about a crash test. Vehicles usually impact a solid concrete wall at a specified speed, but these can also be vehicle impacting vehicle tests. SUVs have been singled out in these tests for a while, due to the high ride- height that they often have.
- **Moderate Overlap tests:** in which only part of the front of the car impacts with a barrier (vehicle). These are important, as impact forces(approximately) remain the same as with a frontal impact test, but a smaller fraction of the car is required to absorb all of the force. These tests are often realized by cars turning into oncoming traffic. This type of testing is done by the U.S.A. Insurance Institute for Highway Safety (IIHS), EuroNCAP, Australasian New Car Assessment Program (ANCAP) and ASEAN NCAP.
- **Small Overlap tests:** this is where only a small portion of the car's structure strikes an object such as a pole or a tree, or if a car were to clip another car. This is the most demanding test because it loads the most force onto the structure of the car at any given speed. These are usually conducted at 20% of the front vehicle structure.
- **Side-impact tests**: these forms of accidents have a very significant likelihood of fatality, as cars do not have a significant crumple zone to absorb the impact forces before an occupant is injured.
- **Roll-over tests:** which tests a car's ability (specifically the pillars holding the roof) to support itself in a dynamic impact. More recently, dynamic rollover tests have been proposed in lieu of static crush testing (video).
- **Roadside hardware crash tests:** are used to ensure crash barriers and crash cushions will protect vehicle occupants from roadside hazards, and also to ensure that guard rails, sign posts, light poles and similar appurtenances do not pose an undue hazard to vehicle occupants.
- **Old versus new:** Often an old and big car against a small and new car, or two different generations of the same car model. These tests are performed to show the advancements in crashworthiness.
- **Computer model:** Because of the cost of full-scale crash tests, engineers often run many simulated crash tests using computer models to refine their vehicle or barrier designs before conducting live tests.
- **Sled testing:** A cost-effective way of testing components such as airbags and seat belts is conducting sled crash testing. The two most common types of sled systems are reverse-firing sleds which are fired from a standstill, and decelerating sleds which are accelerated from a starting point and stopped in the crash area with a hydraulic ram.

CRASH ANALYSIS FOR CHANNEL SECTION:

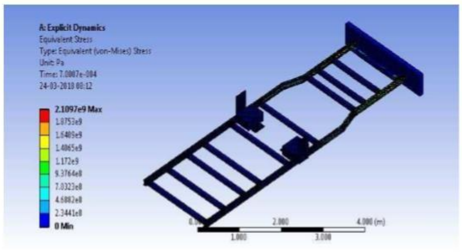


Fig: Von Mises Stress On Channel Section-18m/s

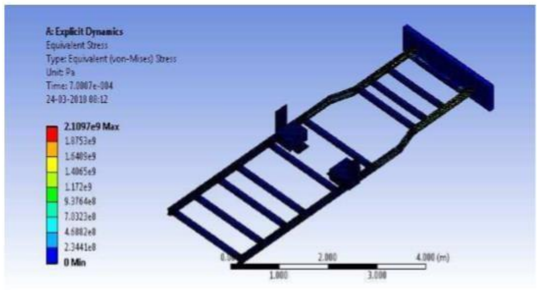


Fig: Von Mises Stress On I- Section-18m/.

RESULTS AND DISCUSSIONS:

*FEA Results For Various Cross Sections:*

One of the main objective of the project was to check for the failure of the fuel tank assembly in the chassis. For ductile materials, the most common failure theories are the maximum shear stress theory and the maximum octahedral shear stress theory. The maximum octahedral shear stress theory is called the Von Mises yield criterion. It states that the material fails if the von Mises stress is greater or equal to the yield stress of the material. Most of the FEA software directly give out the von mises stress. Here the von mises stress of the chassis with fuel tank assembly are compared to the yield stress.

Table: FEA Results For Structural Analysis.

| Parameters | Cross section | | | |
|---|---|---|---|---|
| | Channel section | | I-Section | |
| | AISI 1020 Steel | Alloy Steel | AISI 1020 Steel | Alloy Steel |
| Load in N/m | 2920 | 2920 | 2920 | 2920 |
| Mass in kg | 1838.17 | 1791.64 | 2057.87 | 2005.77 |
| Weight in N | 18032.44 | 17575.98 | 20187.70 | 19676.60 |
| Yield Strength in Mpa | 351.6 | 620.4 | 351.6 | 620.4 |
| Von Mises Stress in MPa | 31.36 | 31.2 | 125.3 | 103.4 |
| Deformation in $10^{-6}$m | 670.5 | 636.6 | 4407 | 2931 |

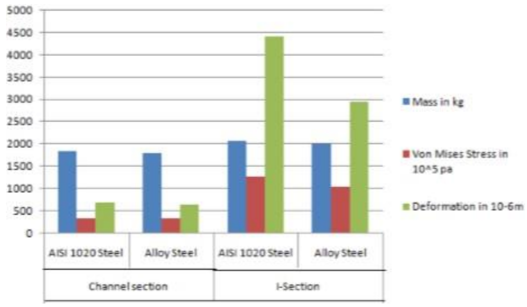


Fig: Comparison Of FEA Results For Channel Section Vs I-Section.

## CONCLUSION:

The following conclusion were drawn from our project work. The weight of channel section is 17575.98N and weight of I- section chassis is 19676.60N.The weight of the channel section chassis is reduced by 10.67% than I-section chassis. The von mises stress of channel section is safe under structural analysis for normal load 2920N/m and is safe under crash test upto 75.6Km/hr. From the above results we conclude that channel frame section is reduced in weight and safe under static and crash analysis for optimum load and speed condition.

**Some scope for future work:** Side impact of the chassis can be performed. Side impact can be better load case to check for the failure of the tanks as in side impact the tanks are more vulnerable to fail. The crash analysis of the pressurized tanks can be performed.

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