Crash Analysis of Vehicle

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Abstract - *Vehicle crash is highly non-linear transient dynamics phenomenon. During an automobile crash some parts will have plastic deformation and absorb a lot of energy. Hence it becomes necessary to check the car structure for its crash ability so that safety is achieved together with fuel economy. Computational simulations and various results are plotted and analyzed. The chassis forms the backbone of vehicle; its principle function is to safely carry the maximum load for all designed operating condition. It must also withstand static and dynamic loads without undue deflection or distortions. The crash analysis simulation and results can be used to assess both the crashworthiness of designed chassis and to investigate ways to improve design. It is an integral part of design cycle and can reduce the need for costly destructive testing program. The concept of Finite Element Analysis of chassis has been highlighted in this project. The chassis is designed using Creo-2.0 and then the analysis is done with the help of analysis software ANSYS and then after comparing the optimum design is selected.*

Key Words: Automobile Crash, Simulation, Chassis Designing. ANSYS, operating conditions.

1. INTRODUCTION

With the development of society, people have increasing demand of vehicles. Car accidents are happening every-day. Most drivers are convinced that they can avoid such troublesome situation. However, the statics shows that many are dead and thousands to millions are injured every year. Car body light weighting and crash-worthiness are two important aspects of design. During an automobile crash, some parts in the front of automobile body may have plastic deformation and absorb a lot of energy. Structural members of a vehicles are designed to increase this energy absorption efficiency and thus to enhance the safety and reliability of the vehicle. Hence, improvement of safety of automobile is must.

1.1 Objective

Crash simulations are used to investigate the safety of the car occupants during impact on the front end structure of the car in a frontal impact, the lateral structure of the car in a side collision, the rear end structure of a car in a rear impact. Crash simulation can also be used to assess injury for the pedestrian. However, the main objectives can be given as-

- To ensure the safety of driver.
- Selection of material on the basis of strength.
- Minimizing the weight of the vehicle without compromising with safety.
- To reduce the cost for actual crash testing.
- The results can be used to assess both the crashworthiness of frames and to investigate the ways to improve the design.

1.2 Scope

The main purpose of a crash analysis is to see how the car will behave in frontal or/and sideways collisions. Car body light weighting and crashworthiness are two important aspects which are considered while designing any vehicle. The chassis frame forms the backbone of the vehicle. Its main function is to carry maximum load for all designed operating condition. This is a part of designing cycle which can reduce the need for costly destructive testing program. This method has a great scope in all automobile industry as it reduces the cost of actual crash testing of the vehicle. Due to participation of various companies the customers have a variety of vehicles to choose. Hence, all the companies are adopting this method of simulation to minimize the weight as well as to make the vehicle safe.

1.3 Methodology

Crash-testing requires a number of the test vehicle to be destroyed during the course of the tests and is also time consuming and uneconomical. One new recent trend that is gaining vast popularity is computer simulated crash-testing. Here instead of a real vehicle, a FE (Finite Element) model of the vehicle is generated and is used to carry out the different tests that were carried out before using actual vehicles. There are several software packages that are equipped to handle the crash-testing of vehicles, but one of the most popular is ANSYS. We are using ansys software for the crash simulation. A static as well as dynamic analysis is done using the software. A chassis is designed and is tested by simulation and the results are used to optimize the vehicle in chassis design and safety. The analysis of the vehicle is calculated at a speed of 40 km/h. The actual speed of the vehicle can vary with the designed speed.

2. DESIGNING

2.1 Objective

To build chassis to meet the entire optimum design parameters frame must be:

- Keep driver alive during 4g front force impact & 3g side impact.
- Keeping low weight of frame as possible.
- Have mounting structure for all subsystems that will withstand the loads produced by those subsystems.
- To withstand centrifugal force while cornering.
- To withstand the forces caused due to sudden braking and acceleration.

2.2 Methodology

Different types of chassis are available for designing the vehicle frame. Here we have selected space frame chassis. Most commonly used method is that in which a manikin is taken as a reference and all the other parameters are designed accordingly. The safety and comfort are the two aspects that are considered for the designing of vehicle. The design methodology adopted is as follows-

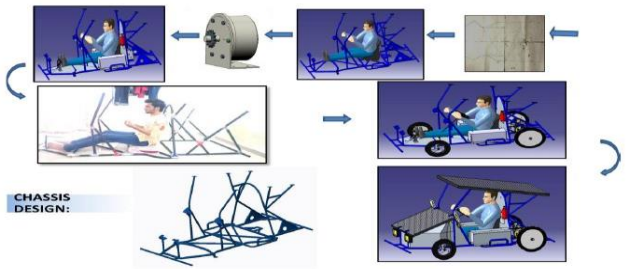

Fig -1: Methodology

2.3 Materials

There are varieties of materials used today for the manufacturing of chassis. Different vehicles have different demands of materials due to various applications. The materials are chosen according to the application of the vehicle. Heavy duty vehicles need a material having high strength, while the light duty vehicles do not have such need. One of the important aspects is the sustainability. There are few properties which are considered during the selection of materials. Those are as follows-

- Light weight
- Economic effectiveness
- Safety
- Recycling

There is wide variety of materials in the market available which are used composite materials, Carbon fibre etc. Out of all the materials, steel is majorly used as it has good qualities that are required for the manufacturing of the chassis frame. Other than steel, Aluminium is used due its light weight. Carbon fibre is light as well as it is stronger but it is not economical. There are other materials too like titanium etc, but they are not used as they are too costly. Some of the important materials with their properties are stated below-

Al 6061

- Density = 2.7g/cc
- Ultimate tensile strength = 310 MPa
- Tensile yield strength = 276 MPa
- Young's modulus = 68.9 GPa
- Poisons ratio = 0.33
- Major application – Aircraft fitting, camera lens mount, coupling, marine fitting, brake pistons, hydraulic pistons, bike frame etc.

AISI 4130

- Density = 7.85g/cc
- Ultimate tensile strength = 560 Mpa
- Tensile yield strength = 460 Mpa
- Young's modulus = 190-210 GPa
- Poisons ratio = 0.27-0.3
- Major application – Aircraft engine mounts, welding tubing etc.

AISI 1018

- Density = 7.87g/cc
- Ultimate tensile strength = 440 MPa
- Tensile yield strength = 370 MPa
- Young's modulus = 205 GPa
- Poisons ratio = 0.29
- Major application – manufacturing of chassis, fixtures, mounting plates and spacers, used to prevent cracking in severe bends.

3. FINITE ELEMENT ANALYSIS

- Finite element analysis is a numerical technique to handle complex geometry, any material properties, any boundary condition and any loading condition.
- Mathematical model of any geometric model describes the behavior of geometry by differential equation and boundary condition.
- Mathematical model is dividing the object of interest into finite number of elements.
- The term degree of freedom is commonly used for physical object.
- If the number of degree of freedom is finite, the model is called discrete and continuous.
- When the physical object is divided into discrete parts, then the infinite degree of freedom is converted into finite degree of freedom.
- Each part of the discretized body is called element.
- Every element has one or more nodes.
- Elements are connected to each other through these nodes.

- Displacement boundary conditions and surface loading conditions are the constraints.

3.1 Chassis 1

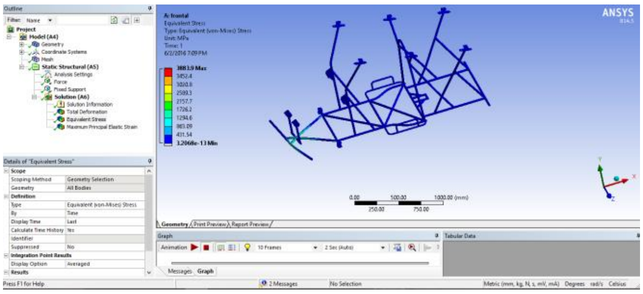

Fig -2: Front Stress (Structural Steel)

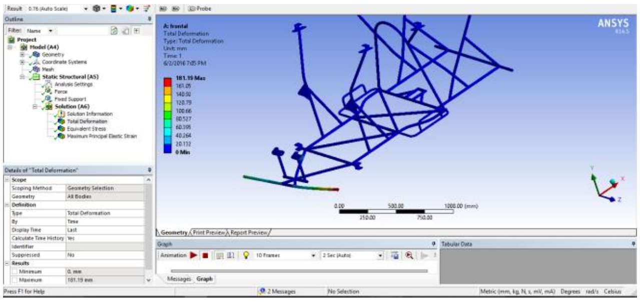

Fig -3: **Front Deformation (Structural Steel)**

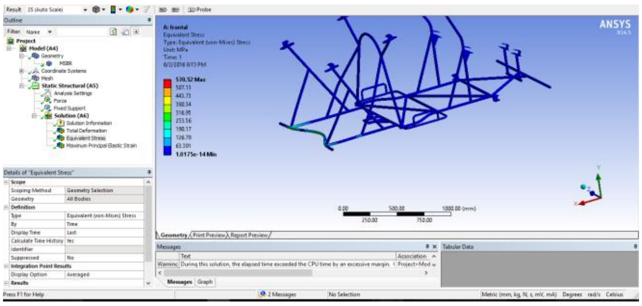

Fig -4: Rear Stress (Structural Steel)

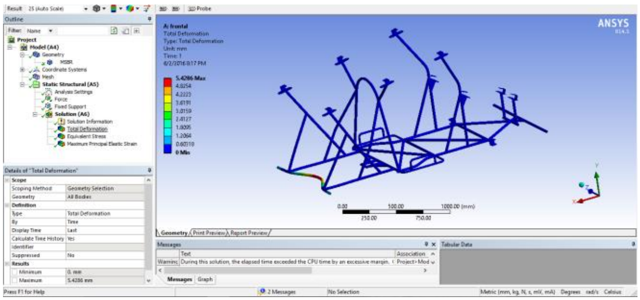

Fig -5: Rear Deformation (Structural Steel)

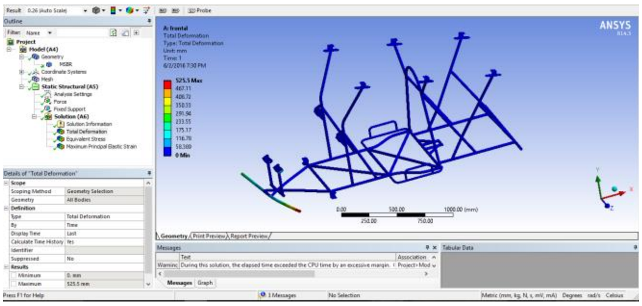

Fig -6: Front Deformation (AL 6061)

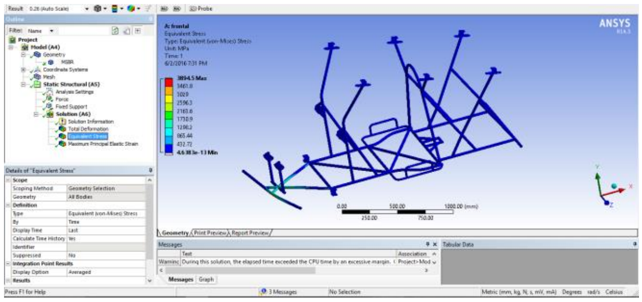

Fig -7: Front Stress (AL 6061)

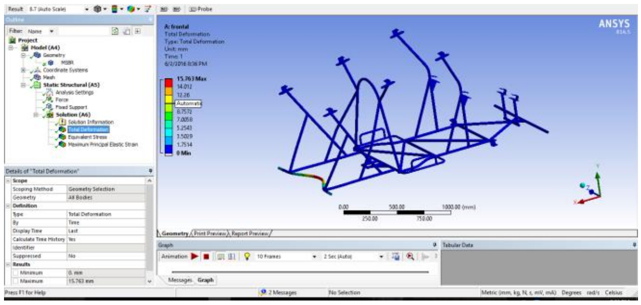

Fig -8: Rear Deformation (AL 6061)

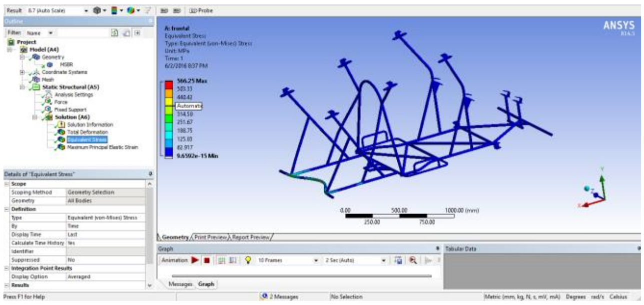

Fig -9: Rear Stress (AL 6061)

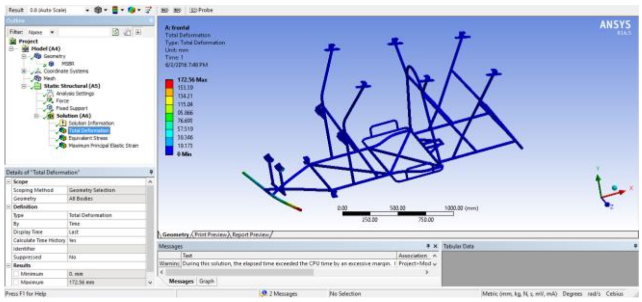

Fig -10: Front Deformation (AISI 4130)

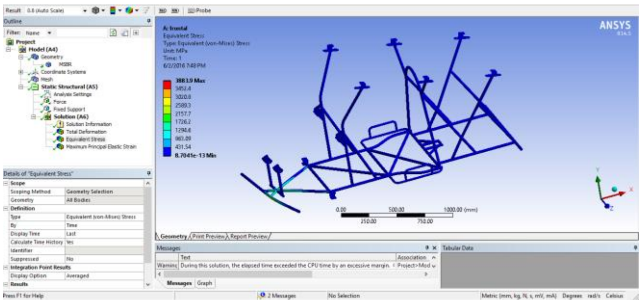

Fig -11: Front Stress (AISI 4130)

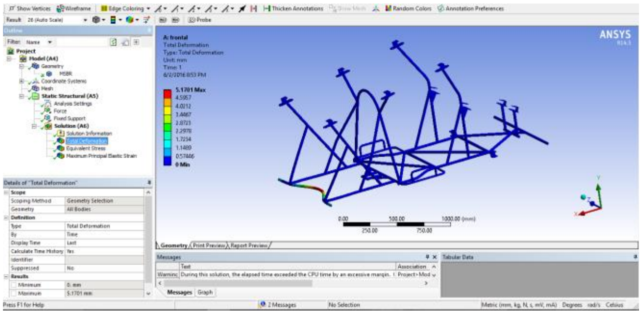

Fig -12: Rear Deformation (AISI 4130)

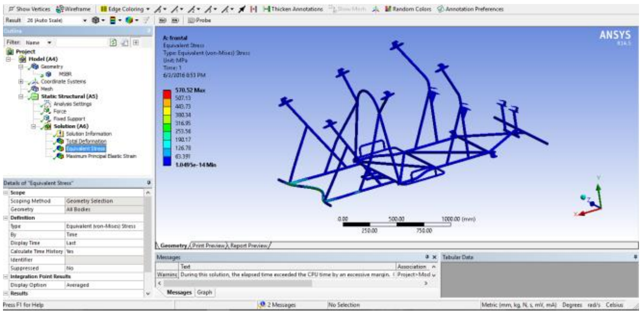

Fig -13: Rear Stress (AISI 4130)

3.2 Chassis 2

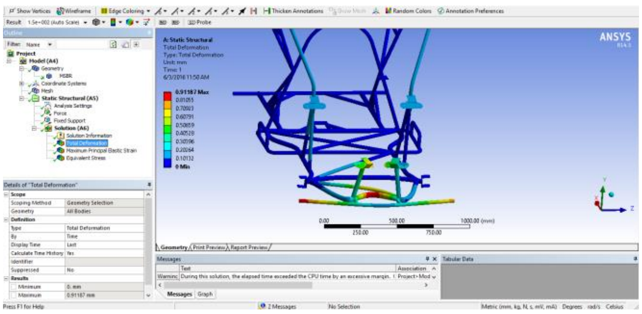

Fig -14: Front Deformation (Structural Steel)

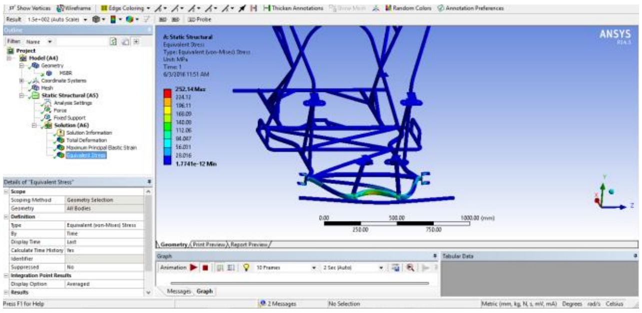

Fig -15: Front Stress (Structural Steel)

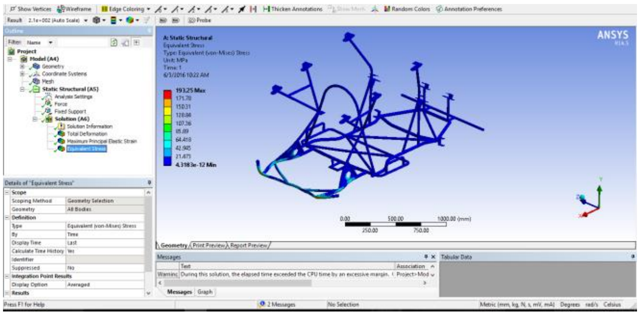

Fig -16: Rear Stress (Structural Steel)

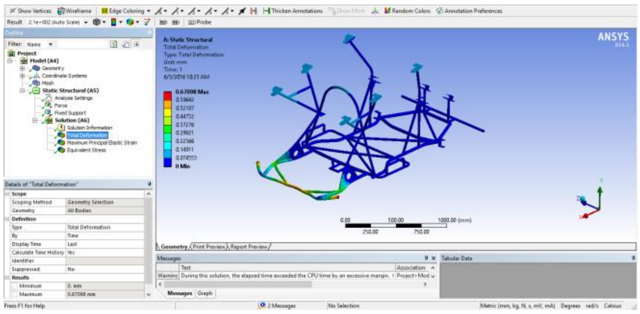

Fig -17: Rear Deformation (Structural Steel)

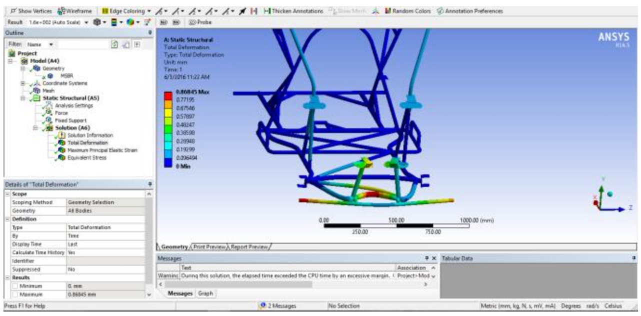

Fig -18: Front Deformation (AISI 4130)

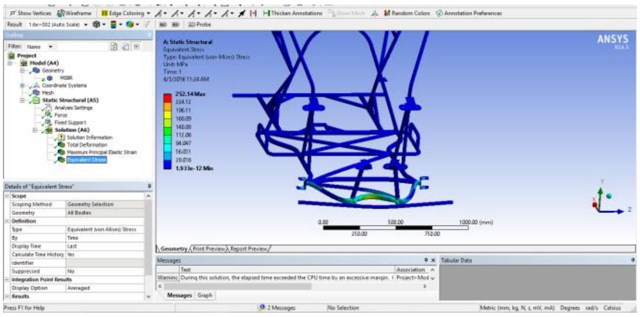

Fig -19: Front Stress (AISI 4130)

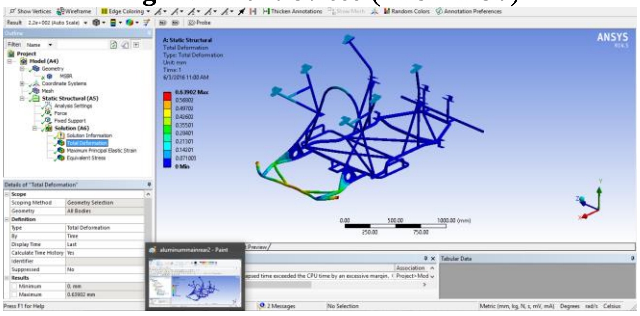

Fig -20: Rear Deformation (AISI 4130)

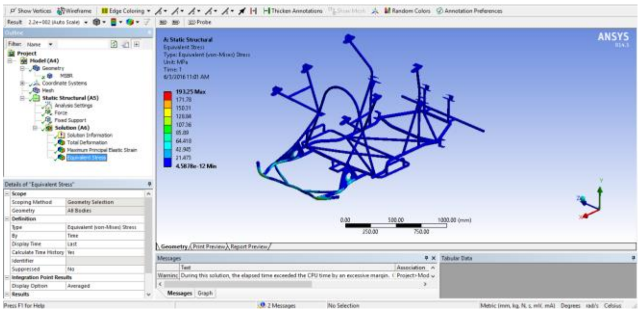

Fig -21: Rear Stress (AISI 4130)

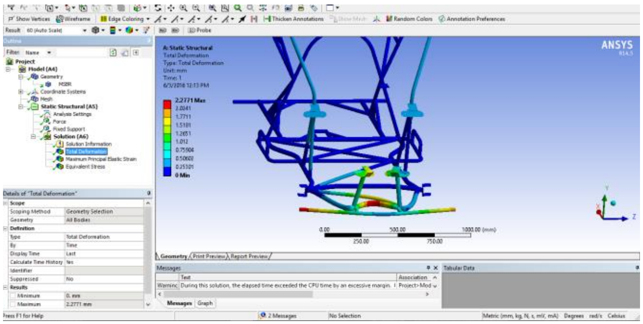

Fig -22: Front Deformation (AL 6061)

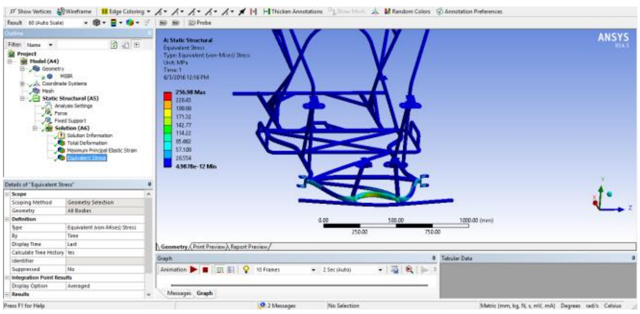

Fig -23: Front Stress (AL 6061)

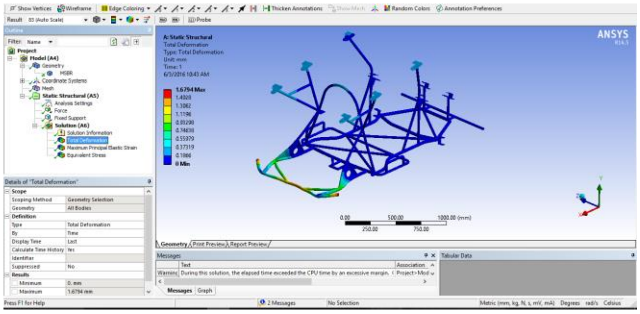

Fig -24: Rear Deformation (AL 6061)

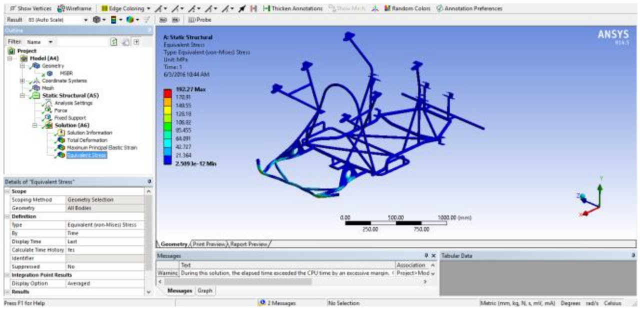

Fig -25: Rear Stress (AL 6061)

4. ADVANTAGES

- The actual destruction of the vehicle is avoided.
- The crash test using simulation becomes economical.
- A variety of model can be tested for the same FEA model.
- The results are used to assess both the crashworthiness and to investigate the ways to improve the design.

5. CONCLUSION

In day-to-day life, the lives of human beings are of utmost importance. For the safety of human beings, the vehicle should be safer against the various impacts on the vehicle. The chassis is the backbone of the vehicle. The main purpose of the chassis is to withstand the designed load and provide support for the mounting of different systems on the vehicle. The aim of this project was to design a safer, lighter and economical chassis using iterations for the safety of the vehicle in analysis software. The design is optimized and the weight factor along with the safety consideration is kept in view while designing the chassis. The material is selected based on the desired properties for the chassis. The actual cost for the crash testing of the vehicle is saved. Hence, the overall cost of the vehicle is also reduced. the machine is prepared by designing and manufacturing the components, and assemble these components with standard available parts. The machine setup is then tested to ensure its satisfactory performance. During the testing it is found that, the machine is able to work with specified rpm and sufficient turbulence is created inside the mixing chamber. The vibrations created during running condition are much less. These all results in homogenous mixing of contents in the mixing chamber, which is our main objective. The problem is that the machine is able to work in particular range of viscosity and it is able to handle the limited capacity for which it is previously designed. For given conditions the performance of machine is found to be satisfactory. In future for large capacity tanks concept of baffling, sensors and concept of square vessel are also suggested.

6. FUTURE SCOPE

We have seen that minimum energy should be transmitted to the driver when the car crashes. Hence, bumper system can be used. The bumper of a car can be made as a sandwich model or spring. Sandwich model or spring can be used in bumper in order to reduce the impact that is transferred to passenger compartment. Analysis of this design can be done which may yield to better safety. These designs may also reduce weight of bumper leading to increase the fuel efficiency. FEA analysis has a great future in various industries. The various softwares involved can be used for various findings in the industries. Separate analysis of parts of a machine can be done for finding out the defective part. Various materials can be also tested using the same FEA model. The endurance limit of the materials and components can be tested. FEA modeling considers dynamic analysis too. Hence, real time forces can be applied to the components for testing their endurance limit. The lives of the components can also be estimated by the analysis. Fatigue failure can also be determined. Now-a-days various companies are adopting this method to make their components more reliable and safer. Quality products are in demand by the consumers. Hence, adopting the FEA method a reliable and a good quality product is being manufactured.

REFERENCES

[1] THE OFFSET CRASH TEST -A COMPARATIVE ANALYSIS OF TEST METHODS (Tomiji Sugimoto, Yoshiji Kadotani, Shigeru Ohmura Honda R&D Co., Ltd., Japan M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] COMPARISON OF UNIVERSITY OF MICHIGAN CIREN CASES TO EXISTING TYPES OF CRASH TESTS (Bridget O'Brien-Mitchell, Kacy Bailey, Daniel Faust, Jack Jensen, Julie Kleinert, Christine Wodzinski, Stewart Wang. University of Michigan Program for Injury Research and Education United States).

[3] PASSENGER VEHICLE CRASH TEST PROCEDURE DEVELOPMENTS IN THE VC-COMPAT PROJECT Robert Thomson Chalmers University of Technology Sweden Mervyn Edwards TRL, Limited (Transport Research Laboratory) United Kingdom.

[4] Design And Development Of Roll Cage For An All Terrain Vehicle Khelan Chaudhari, Amogh Joshi, Ranjit Kunte, Kushal Nair.