DESIGN AND OPTIMIZATION OF HTV FUEL TANK ASSEMBLY BY FINITE ELEMENT ANALYSIS

P.Laxminagaprasad[1], P.Shashidar[2] , Rajeev Achrya[3]

[1] *Mechanical Engineering, Sri Venkateswara Engineering College (India)*
[3] *Mechanical Engineering, MGIT College (India)*
3 Mechanical Engineering, Sri Venkateswara Engineering College College (India)

ABSTRACT

The present study is a methodology to improve the design by keeping the stresses within the allowable limit and by improving the first natural frequency of a fuel tank brackets for heavy duty vehicles using FEA. To improve the performance of the fuel tank bracket series of design iteration was carried out by taking the account of base model structure.

Key Words: Fuel Tank, Duty Vehicles, Structure.

I INTRODUCTION

The first heavy duty trucks were developed in United States in the late 1890s. During World War 1heavy duty truck played an important role in moving supplies at home and overseas. Fuel tanks in the heavy duty trucks were made with steel because of high strength and durability. Fuel tank is a safe container for flammable fluids. The fuel system of automobile vehicles should perform within major safety parameters related to the importance of flammable substances such as diesel fuels which is extensively consumed worldwide. Important consideration in designing a fuel tank are determining placement choosing the shape and determining the required volume. The fuel system of automobile chassis body system may undergo undesirable vibration due to disturbance from road and fuel tank system. In order to control the road induced vibration the fuel tank bracket should be stiff and damped. Fuel tank mounting is accomplished with use of brackets, straps or a combination of both for the purpose of attaching the fuel tank to the truck frame.

II USES

Typically, a fuel tank must allow or provide the following:

- Storage of fuel: the system must contain a given quantity of fuel and must avoid leakage and limit evaporative emissions.
- Filling: the fuel tank must be filled in a secure way, without sparks.

- Provide a method for determining level of fuel in tank, gauging (the remaining quantity of fuel in the tank must be measured or evaluated).

1. 3 Fuel Tank Construction

While most tanks are manufactured, some fuel tanks are still fabricated by metal craftsmen or hand-made in the case of bladder-style tanks. These include custom and restoration tanks for automotive, aircraft, motorcycles, and even tractors. Construction of fuel tanks follows a series of specific steps. The craftsman generally creates a mockup to determine the accurate size and shape of the tank, usually out of foam board. Next, design issues that affect the structure of the tank are addressed - such as where the outlet, drain, fluid level indicator, seams, and baffles go. Then the craftsmen must determine the thickness, temper and alloy of the sheet he will use to make the tank. After the sheet is cut to the shapes needed, various pieces are bent to create the basic shell and/or ends and baffles for the tank. Many fuel tanks' baffles (particularly in aircraft and racecars) contain lightening holes. These flanged holes serve two purposes, they reduce the weight of the tank while adding strength to the baffles. Toward the end of construction, openings are added for the filler neck, fuel pickup, drain, and fuel-level sending unit. Sometimes these holes are created on the flat shell, other times they are added at the end of the fabrication process. Baffles and ends can be riveted into place. The heads of the rivets are frequently brazed or soldered to prevent tank leaks

1.4 Automotive Fuel Tanks

The maximum distance a combustion-engine powered car with a full tank can cover is the product of the tank capacity and its fuel efficiency (as in miles per gallon). While larger tanks increase the maximum distance, they also take up more space and (especially when full) add to the total weight, requiring higher fuel consumption for the same performance. Fuel-tank capacity is therefore the result of a trade-off in design considerations. For most compact cars, the capacity is in the range 45–65 litres (12–17 US gal); the original model Tata Nano is exceptional with its 15 litres (4 US gal) fuel tank. SUVs and trucks tend to have considerably larger fuel tanks.

For each new vehicle a specific fuel system is developed, to optimize the use of available space. Moreover, for one car model, different fuel system architectures are developed, depending on the type of the car, the type of fuel (gasoline or diesel), nozzle models, and region.

1.5 Safety

Proper design and construction of a fuel tank play a major role in the safety of the system of which the tank is a part. In most cases intact fuel tanks are very safe, as the tank is full of fuel vapour/air mixture that is well above the flammability limits, and thus cannot burn even if an ignition source were present (which is rare).

Bunded oil tanks are used for safely storing domestic heating oil and other hazardous materials. Bunding is often required by insurance companies, rather than single skinned oil storage tanks.

Several systems, such as BattleJacket and rubber bladders, have been developed and deployed for use in protecting (from explosion caused by enemy fire) the fuel tanks of military vehicles in conflict zones.

II INTRODUCTION TO CAD/CAM/CAE

The Modern world of design, development, manufacturing so on, in which we have stepped can't be imagined without interference of computer. The usage of computer is such that, they have become an integral part of these fields. In the world market now the competition in not only cost factor but also quality, consistency, availability, packing, stocking, delivery etc. So are the requirements forcing industries to adopt modern technique rather than local forcing the industries to adapt better techniques like CAD / CAM / CAE, etc.

2.1 Need for CAD, CAE & CAM

The usage of CAD CAE & CAM have changed the over look of the industries and developed healthy & standard competition , as could achieve target in lean time and ultimately the product reaches market in estimated time with better quality and consistency . In general view, it has lead to fast approach and creative thinking.

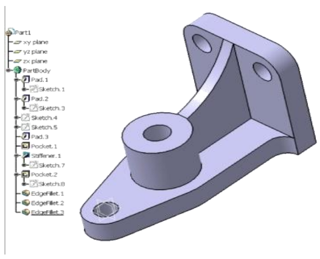
2.2 Introduction to CATIA

CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies in CATIA, and how to make simple drawings of those parts and assemblies.

Feature-based

Like an assembly is made up of a number of individual parts, a CATIA document is made up of individual elements. These elements are called features.

When creating a document, you can add features such as pads, pockets, holes, ribs, fillets, chamfers, and drafts. As the features are created, they are applied directly to the work piece.



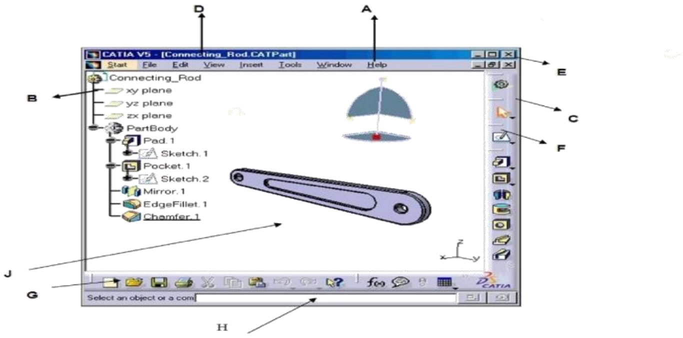
International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 01, January 2017
www.ijates.com
ijates
ISSN 2348 - 7550

Solid Modeling

A solid model is the most complete type of geometric model used in CAD systems. It contains all the wireframe and surface geometry necessary to fully describe the edges and faces of the model. In addition to geometric information, solid models also convey their ―topology‖, which relates the geometry together. For example, topology might include identifying which faces (surfaces) meet at which edges (curves). This intelligence makes adding features easier. For example, if a model requires a fillet, you simply select an edge and specify a radius to create it.

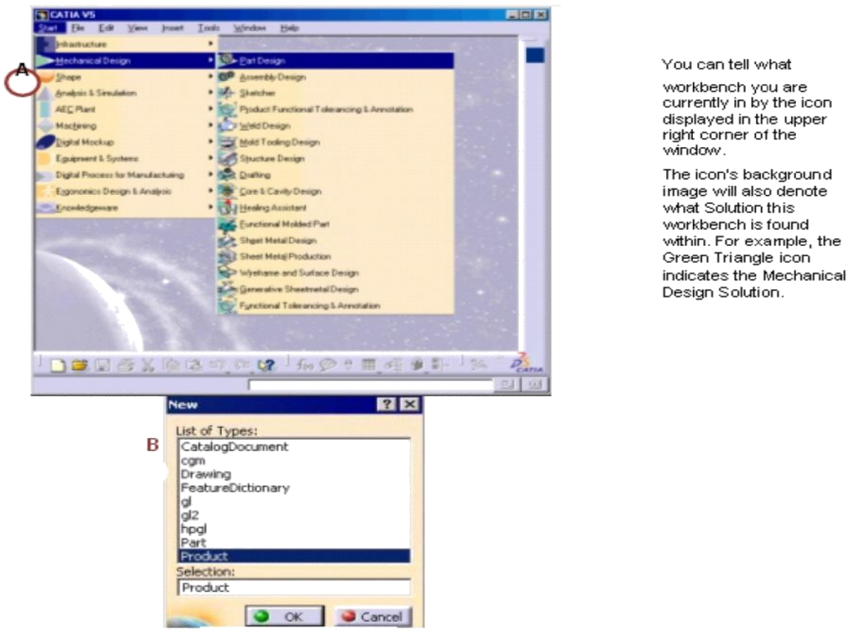
Fully Associative

A CATIA model is fully associative with the drawings and parts or assemblies that reference it. Changes to the model are automatically reflected in the associated drawings, parts, and/or assemblies. Likewise, changes in the context of the drawing or assembly are reflected back in the model.



Workbenches

Workbenches contain various tools that you may need to access during your part creation. You can switch between any primary workbenches using the following two ways:



III FINITE ELEMENT ANALSYS

The finite element analysis (finite element method) is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations. The solution approach is based on either eliminating the differential equation completely (steady state problems) or rendering the partial differential equation into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method, Runge-Kutta method etc

IV ANSYS

ANSYS is a general-purpose finite element-modeling package for numerically solving a wide variety of mechanical problems. These problems include: static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems.

V OBJECTIVE OF THE PRESENT WORK

The objectives of the project are as follows

To develop structural modeling of fuel tank and bracket using CATIA
To perform Modal analysis of fuel tank and bracket by using Ansys 15 for finding natural frequency for basic design
To perform finite element analysis of fuel tank and bracket by using Ansys 15 for structural steel material for the basic design
Perform design modifications on basic design to improve natural frequency and avoid high stress locations.

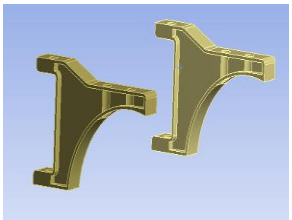
5.1 Scope of Project

To improve the first natural frequency of a fuel tank brackets for heavy duty vehicles using FEA. To improve the performance of the fuel tank bracket series of design iteration was carried out by taking the account of base model structure. Normal modal analysis for base model is carried out to find the first natural frequency. Normal modal analysis was carried for all the design iteration to improve the first natural frequency of the fuel tank bracket. Static analysis is carried out for all modified designs to find out the Maximum displacement and von misses stress at critical location.

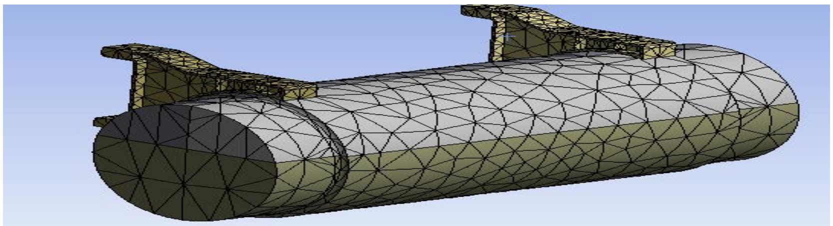
VI STATIC STRUCTURAL & MODAL ANALYSIS

The computer aided design of base model fuel tank mount bracket is shown in figure 6.1. This bracket has been assigned to various design modification by adding stiffeners to base design. Finite Element Analysis is carried out by using ANSYS software.

ijates
ISSN 2348 - 7550



The model is meshed with tetrahedrons second order elements. The meshed model is shown in below figure.

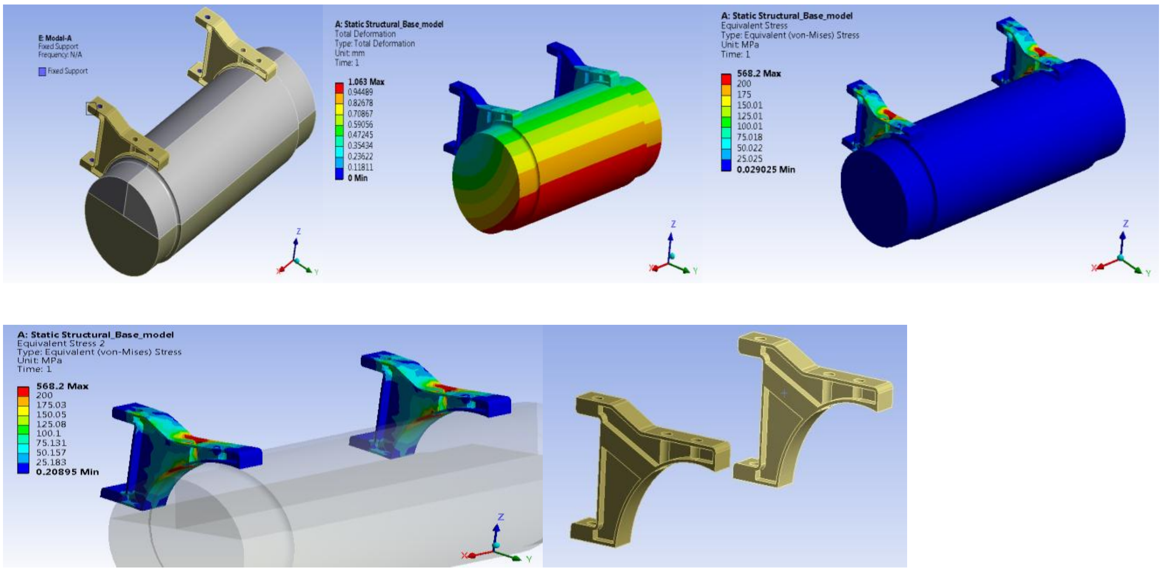


Statistics	
Nodes	11279
Elements	5733
Mesh Metric	None

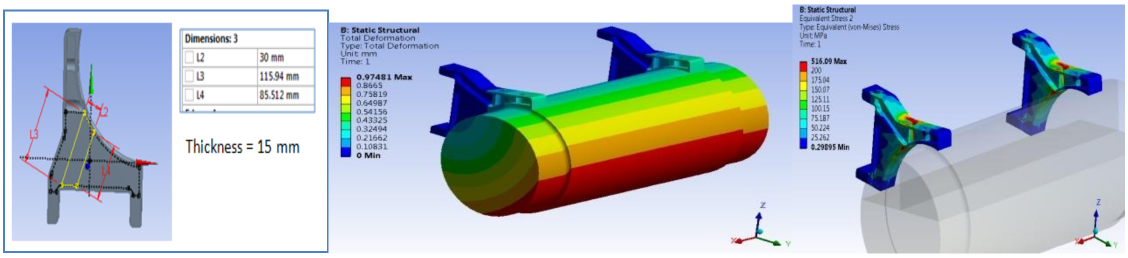
Element Type: Solid 187(Tetrahedral second order element)

6.1.1 Loads & Boundary conditions:

Bolt holes of the brackets are fixed in all degrees of freedom. Gravity load applied to the model. Loads & Boundary conditions applied to the model is shown in below figure



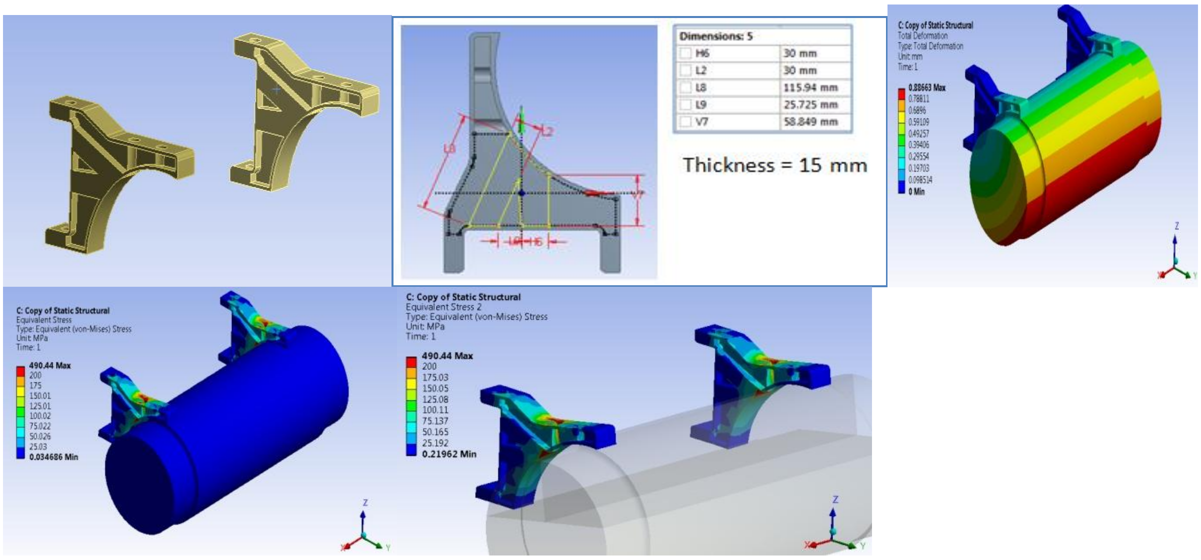
ijates
ISSN 2348 - 7550



6.2.3 Design Modification -2

Geometry

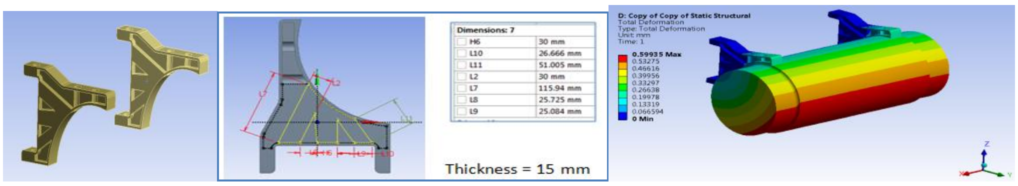
From the results observed in the basic design the brackets are getting high stress, to avoid the high stress the following design modification is praposed with adding two stiffners to the existing bracket and FE analysis performed on the modified design.

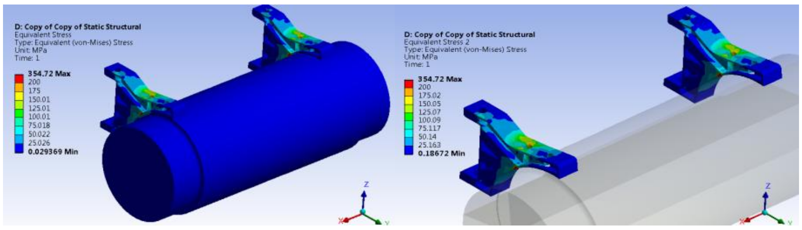


6.2.4 Design Modification -3

Geometry

From the results observed in the basic design the brackets are getting high stress, to avoid the high stress the following design modification is praposed with adding multi stiffners to the existing bracket and FE analysis performed on the modified design.





6.4 Results Summary

The results for the basic design and design modifications are represented in below table.

Design	Deformation (mm)	von Mises Stress (MPa)
Basic Design	1.06	568
Design Mode 1	0.97	516
Design Mode 2	0.88	490
Design Mode 3	0.59	354

VII CONCLUSION

A successful effort has been made to predict the Eigen values and Eigen vectors of fuel tank mounting brackets assembly by numerical simulation. By comparing the results of all design iterations the following conclusions are made.static structural analysis we came to the conclusion that the brackets with multi stiffeners i.e. design modification 3 are giving good results of deformation of 0.59mm and von mises stress of 384MPa. which are minimal values as compare with basic and other design modifications.From the Normal mode analysis that the first natural frequency of multi stiffener fuel tank mounting bracket is 73Hz is good compare to other stiffeners.

REFERENCES

1. Umesh s ghorpade, Mahendra gaikwad " FEA and natural frequency optimization of engine bracket" IJMIE, Vol-2, Iss-3, 2012.
2. Tatsuo kasuga, Eisei higuchi, "method and structure for mounting a fuel tank" US5794979 A.
3. Pavan B. chaudhari, "comparison of Mg, Al and cast iron to obtain optimum frequency of engine bracket using FEA" IJERA, Vol-2, sep-oct 2012.

4. Jasvir Singh Dhillon, Priyanka Rao, ”design of engine mount bracket for FSAE car using finite element analysis” IJERA, Vol-4, Iss-9(version 6), September 2014.

5. Michael Davis, Zhingxing fu, Qunhui Han, “optimizing fuel tank design for high speed vehicles ”June 9-12 2009.

6. ^ Howstuffworks "Transmission Basics"

7. ^ Norton 2004, p. 462

8. ^ Lewis, M. J. T. (1993). "Gearing in the Ancient World". *Endeavour* **17** (3): 110–115 [p. 110]. doi:10.1016/0160-9327(93)90099-O.

9. ^ "The Antikythera Mechanism Research Project: Why is it so important?", Retrieved 2011-01-10 Quote: "The Mechanism is thought to date from between 150 and 100 BC"

10. ^ [a b c d] *ANSI/AGMA 1012-G05*, "Gear Nomenclature, Definition of Terms with Symbols".

11. ^ Khurmi, R.S, *Theory of Machines*, S.CHAND

12. ^ Schunck, Richard, "Minimizing gearbox noise inside and outside the box.", *Motion System Design*.

13. ^ Doughtie and Vallance give the following information on helical gear speeds: "Pitch-line speeds of 4,000 to 7,000 fpm [20 to 36 m/s] are common with automobile and turbine gears, and speeds of 12,000 fpm [61 m/s] have been successfully used." – p.281.

14. ^ [a b] *Helical gears*, retrieved 15 June 2009.

15. ^ *McGraw Hill Encyclopedia of Science and Technology*, "Gear", p. 742.

16. ^ Canfield, Stephen (1997), "Gear Types", *Dynamics of Machinery*, Tennessee Tech University, Department of Mechanical Engineering, ME 362 lecture notes.

17. ^ Hilbert, David; Cohn-Vossen, Stephan (1952), *Geometry and the Imagination* (2nd ed.), New York: Chelsea, pp. 287,ISBN 978-0-8284-1087-8.

18. ^ *McGraw Hill Encyclopedia of Science and Technology*, "Gear, p. 743.

19. ^ Vallance Doughtie, p. 287.

20. ^ Vallance Doughtie, pp. 280, 296.

21. ^ Doughtie and Vallance, p. 290; McGraw Hill Encyclopedia of Science and Technology, "Gear", p. 743.

22. ^ *McGraw Hill Encyclopedia of Science and Technology*, "Gear", p. 744.