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Stress Analysis on HDPE fuel tank for Maruti Alto Car

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ABSTRACT

The aim of this project is to design a HDPE fuel tank based on existing design, which is already used in Maruti alto car as same specification of original steel tank and obtain a comparative study on weight and different factor using material as High Density Poly-Ethylene.as to obtain a comparative study. The project consists of optimization of the model to get best design outputs obtained from analysis results and then modified the HDPE model. This modification are based on changing the shape of the existing model by taking advantage of the metallurgical properties of HDPE and Analyzing it on the same parameters of the original fuel tank.

Keywords: HDPE, Fuel Tank, Analysis.

I. INTRODUCTION

Plastic fuel tanks instead of steel tanks have been used in recent years due to their several advantageous properties such as their light weight, low material and production costs, high safety levels, greater capacity due to greater choice of shape, non-corrosiveness property and good design flexibility In 1972, VW Passat cars with plastic fuel tanks were manufactured for the first time as a mass production. Since then the major automobile manufacturers around the world have started to show interest in and to work on the use of the plastic fuel tanks.

Plastic fuel tanks date back to the early 1950's. The success of Volkswagen's use of high molecular weight polyethylene tanks in the early 1970's has considerably influenced the growth of HDPE fuel tanks in North America (WOOD, 1991).During the late1980's and early 1990's, American companies began experimenting with using plastic fuel tanks. Landsberg, Germany Delphi studies forecast that by the year 2000, 40% of all North American-produced passenger cars and light trucks will have plastic fuel tanks and 60% will have steel tanks. By the year 2005, they forecast that 60% of fuel tanks will be made of plastic and 40% will be made of steel.

II. METHODS AND MATERIAL

A. Working Methodology

1) In this project the existing fuel tank of Maruti alto Car is taken and designs it in solid works software used for designing of CAD models. The design of fuel tank is same as original design without changing its dimension and shape.
2) The next step to be the stage free vibration analysis to check the stiffness of design model whether it can sustain the Finite Element Analysis.
3) To third step is perform Finite Element analysis on the model with boundary condition and other test as given in the norms of Automotive Research Association of India (ARAI).
4) To perform the finite element analysis on the model with same condition but replacing material with HDPE (High Density Poly-Ethylene)
5) To optimize the model by having analysis results on different thickness.
6) Selecting appropriate thickness for model as its design should be safe with having some factor of safety.
7) Now, the existing model is modified in its shape in accordance to obtain better results than existing HDPE model results.
8) To compare the existing model and new Model on different parameters shown in below chapters.

B. Material

The materials I have selected for this study are:

1) High spot Density Poly-Ethylene
2) Steel

Material	Density(ρ)Kg/ m3	Young's Modulus (E) GPa	Poisson's Ratio (μ)
HDPE	970 kg/m3	1.2 Gpa	0.3
STEEL	7890 kg/m3	210 Gpa	0.3

C. Modeling And Analysis of HDPE Fuel

The model is design in solid works as per the original specification and geometry used in maruti alto car

Figure 1. Isometric view of the 3d Model.

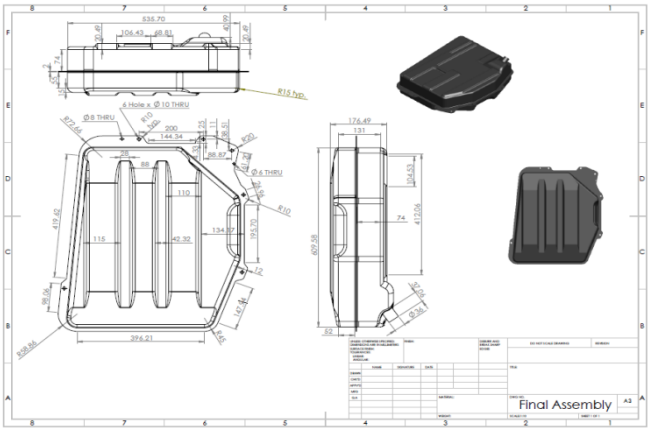


Figure 2. Detailing of the model

✓ **Meshing of the model**

Meshing is a skilfulness in FEA in which model is meshed in small number of elements. There are different types of elements square, rectangular bar triangular element etc.

Table 1. Element count of the meshed model

Sr No	Element Type	Count
1	TRIA	952
2	QUAD	61728
3	RBAR	546

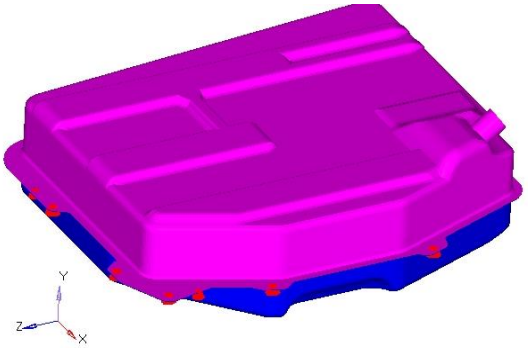


Figure 3. Meshed model

D. Test and Boundary Condition

✓ **Hydraulic Test**

The tank must be subjected to a hydraulic internal pressure test, which must be carried out on an isolated unit complete with all its accessories. The tank must be completely filled with a non-flammable liquid

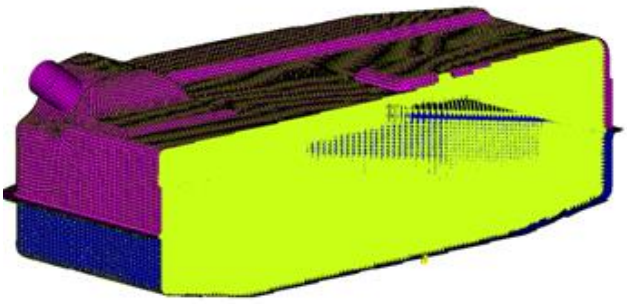


Figure 4. Boundary condition for hydraulic test with internal pressure 0.3 Bar

✓ **Overturn Test**

1) The tank and all its accessories must be mounted on to a test fixture in a manner corresponding to the mode of installation on the vehicle for which the tank is intended; this also applies to a system for the compensation of the interior excess pressure.
2) The test fixture shall rotate about an axis lying parallel to the longitudinal vehicle axis.

3) The test shall be carried out with the tank filled to 90% of its capacity and also 30% of its capacity with a non-flammable liquid having a density and a viscosity close to those of the fuel normally used (water may be accepted)

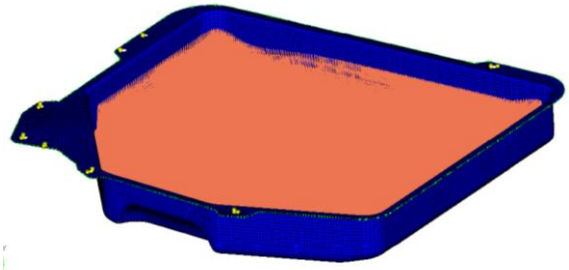


Figure 5. Liquid pressures on bottom face

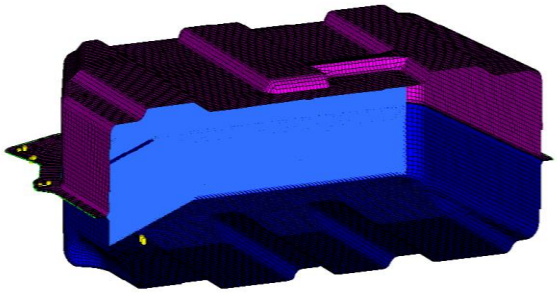


Figure 6. Liquid pressure on left side face

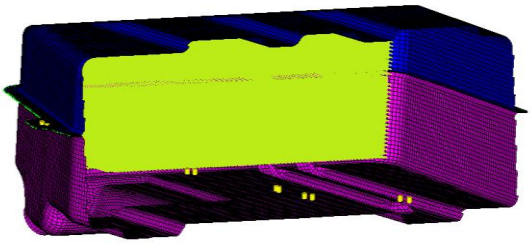
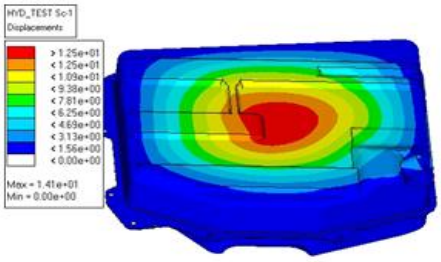


Figure 7. Liquid pressure on right side face

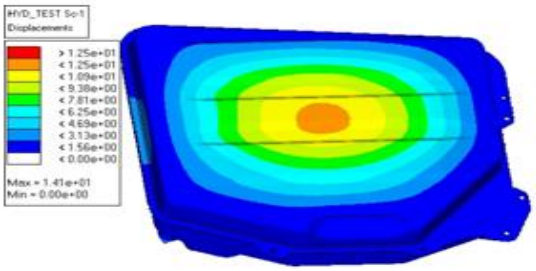
III. ANALYSIS RESULTS

A. F. E. A Result (Hydraulic Test - HDPE) For 5 mm Thick

Displacement Plot:



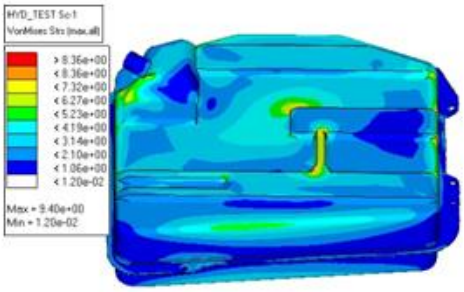
Front Side



Back Side

Figure 7. Maximum displacement = 14.1 mm

Vonmmises Stress Plot



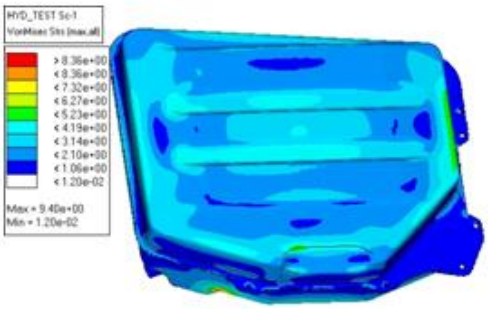


Figure 9. Maximum Vonmmises stress = 9.40 MPa

B. F. E. A Result (Overturn Test - HDPE) For 5 mm Thick

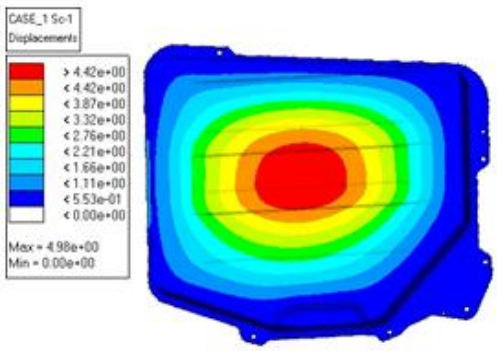


Figure 10. Maximum displacement = 4.98 mm

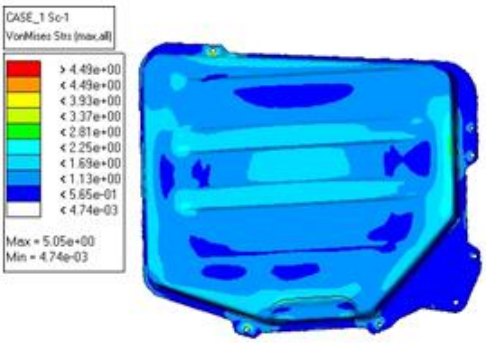


Figure 11. Maximum Vonmmises stress = 5.05 MPa

V. RESULT

As we have carried the hydraulic test and over turn test on various thicknesses for the HPDE, the result of HPDE with 5 mm thickness are safe and also the weight lowered compared to conventional metallic design. Thus we have finalized the design which would be optimized further.

Table 2. Test Results

Hydraulic test				
Metallic			HDPE	
Displacement (mm)	Stress (mpa)	Thickness (mm)	Displacement mm	Stress (mpa)
2.65	162	3	42.5	24.5
		4	23	14.4
		5	14.1	9.40

Table 3. Table showing weight of test conducted

Metallic Weight (kg)	HDPE Weight (kg)	
6.25	3 mm	1.81
	4 mm	2.721
	5 mm	3.628

This table shows the reduction of weight of metallic tank and HDPE tank

IV. CONCLUSION

In this project the objective is to obtain comparative study of fuel tank for Maruti alto car in which the original Design model of steel fuel tank has taken. With related dimension a CAD model is design and performs an FEA analysis on it.

The material used is HDPE (High Density Poly-ethylene) for tank as an alternative with depth of 3mm, 4mm and 5 mm. The 3mm and 4mm is weakness where the depth with 5 mm is safe and under design condition as the yield stress for HDPE material is 15 Mpa

1) For 3mm depth stress is 24.5 Mpa greater then 15 Mpa failing the design Criteria.
2) For 4mm depth stress is 14.4 Mpa near about to 15 Mpa ,which cannot be considered as it has no Factor of safety.
3) For 5 mm depth stress is 9.40 Mpa less then 15 Mpa can be consider an has Factor of safety.

So selecting 5 mm depth for HDPE fuel tank and other parameters are also is safe shown in above tables.

The existing model is also being modified to optimize the model, this optimization has done on the shape of the existing model and shown by Finite Element Analysis, now we can dress warmly that our modified model is better than existing model as is reduce more weight than Existing HDPE Model

The depth of 5mm HDPE fuel tank has stress of 9.40 Mpa and modified HDPE fuel tank of thickness 5 mm has stress 4.16 Mpa but custom-made HDPE fuel tank of depth 4 mm has stress of 8.46 Mpa.

Since the modified design of 5mm depth produces much lower and safe results, thus we have changed the depth back to 4 mm which produces safe result and thus the final designed is selected.

The weight Reduce by 57.31 % as comparison of existing steel Fuel tank and optimized HDPE fuel as shown in above table.

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