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Design and Impact Analysis of Two Wheeler Front Engine Cover

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ABSTRACT

In this project we are designing & analyzing an engine cover made of different metals & plastic materials. Today's ever-increasing demand for newer, lighter materials with higher strength, greater stiffness, and better reliability has led to wide research on development of thermo plastic materials. These materials offer a combination of strength and modulus that are either comparable to or better than many traditional materials such as metals.

However, with the development need for materials with superior properties from the private sector, composites are now making their way into more common applications. However, study on the static optimization and Modal mechanical behaviour, long term durability, and environmental stability of these materials are limited. Under-the-bonnet applications came later with the more widespread availability of high-performance thermoplastics and contributed significantly to cost and weight reduction in the engine compartment.

In the present work an attempt has been made to analyze the different materials for engine cover of vehicle with respect to static and modal analysis. Initially the engine cover model will be prepared in CATIA software. Analysis of engine cover model is done in ANSYS for five different materials and results for existing material will be studied. The objective of present work is to suggest the best material for vehicle engine cover by comparing obtained results with present material.

Keywords:

Engine Cover, FEA, Static Structural Analysis, Topology Optimization, Plastic Material

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1. INTRODUCTION

1.1.Why Engine Cover is used?

- Engine covers are C-shaped brackets usually mounted on motorcycle frames at the front in order to protect the engine mainly from stone impacts, mud etc.
- The covers protect the engine from dust, debris, etc, while adding a cleaner look to the engine bay.
- Because of irregular road surface in India and in other part of country, during rainy season, water from drainage flows over road and fills up the left-over broken roads or crack.
- When vehicle running from contaminated muddy water it may splash over engine and may affect its material for corrosion etc. and small rock particles while driving may come under the impact force towards the engine casing and may cause damage to the casing. To protect from unwanted natural force caused due to hitting of rock particles or accidents; engine covers are used to overcome it.

Figure – Engine Cover

1.2. Significance of Proposed Work

In this project work an attempt will be made to analyze the different materials for engine cover of two-wheeler vehicle with respect to static and modal analysis. Initially the engine cover model will be prepared in CATIA software. Analysis of engine cover is done using ANSYS by importing the CATIA software model for below different materials.

- Steel 4043
- Aluminum 6061 T6
- Poly vinyl chloride (PVC)
- High density polyethylene (HDPE)
- PP GF30

The objective of present work is to suggest the best material for two-wheeler vehicle engine cover by comparing obtained results with present material. The various parameters of interest are natural frequency, total deformation and equivalent stress. Based on results obtained with the study of above parameters ideal material for engine cover will be suggested.

1.3. Objective

- To develop a low weight, low cost, durable and high strength engine cover to protect from unwanted dust, minute solid particles & contaminated water.
- To obtain design stability with superior material performance.
- To investigate impact structural test on the engine cover from front side.
- To investigate the vibration occurrence in the engine cover.
- To optimize the cover for its weight reduction and material selection.
- Finally comparison on different material for better results.

1.4.Methodology

- In this project work an attempt is made to analyze the engine cover of two-wheeler vehicle with respect to static and modal analysis. Initially the engine cover model is designed in CATIA software. Analysis of engine cover is done using ANSYS by importing the CATIA software model for different materials.
- Also the topology optimization for better design is done. Also vibrational modal analysis is done to check natural frequencies.
- The optimized design is analyzed for different materials against static loading.
- The analysis results with different materials like Total deformation, Static stress, Strain and Mass are compared to evaluate the better design with better material.

1.5. Linear Static Structural Analysis Matrix Equation

For a linear static structural analysis, the displacements {x} are solved for in the matrix equation below:

Assumptions:

K = Constant

F = statically applied

- Linear elastic material behavior is assumed
- Small deflection theory is used
- Some nonlinear boundary conditions may be included
- No time-varying forces are considered
- No inertial effects (mass, damping) are included

1.6. Engine Specifications Consideration

- Two-wheeler engine weights generally about 35-40 Kg. It is a very generalized value as it is highly dependent on the bike. Yamaha FZ series engines are heavier (in weight) than of Bajaj AS150 engine or Apache 160's engine, even Bajaj pulsar 150's engine is heavier than pulsar AS 150's engine.
- Engine Weight: 60 lbs = 27.2155 kg = ~28 kg

  = 28 x 9.81 = 274.68 N
- Impact load to be applied on the bracket is equal to engine weight,

  Considering Factor of Safety = 2

  Impact Load = 274.68 x 2 = 549.36 N = ~ 550 N

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2. Engine Cover design and Analysis – Baseline Design

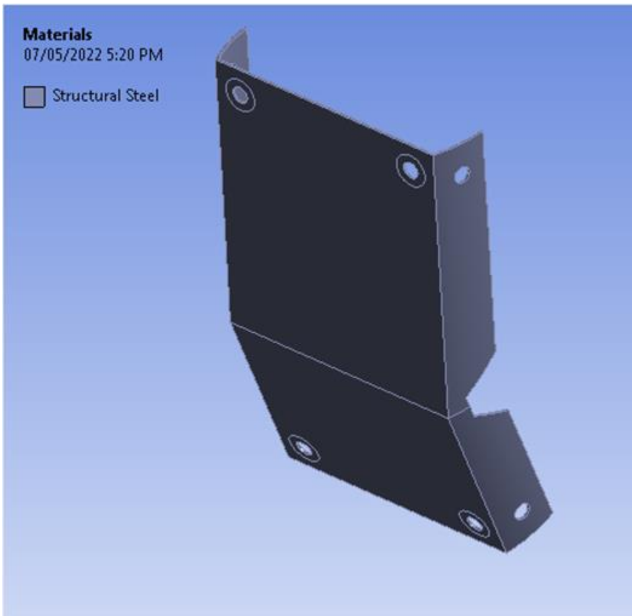
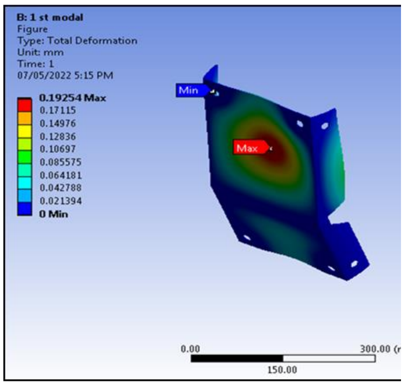
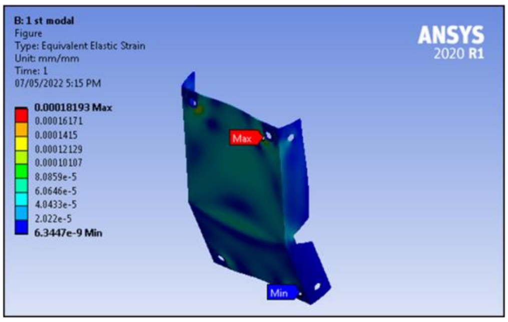


Figure – Cover with material ASTM36 HR

Deformation Plot



Strain Plot



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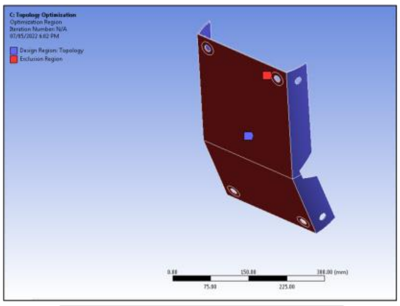
3. Topology Optimization

Topology optimization generates the optimal shape of a mechanical structure. Given a predefined domain in the 2D/3D space with boundary conditions and external loads, the intention is to distribute a percentage of the initial mass on the given domain such that a global measure takes a minimum.

Topology optimization can be implemented through the use of finite element methods for the analysis and optimization techniques based on Homogenization method, optimality criteria method, level set, moving asymptotes and genetic algorithms. A brief discussion on these methods is given below.

- To simulate a part under topology formation, it must be simulated with one of the main modules of system like static, transient, Dynamic, CFD, Model or IC engines etc.
- After the main module boundary processing a topology optimization module or scope is combined with the static structural analysis, results section from static are targeted into the optimization and upon the requirement we can optimize the part for required constraints mode like percentage of reduction of material from part stress based, strain based, vibrational based and mass based.



Design Space for Optimization

Details of "Analysis Settings"

Definition	
Maximum Number Of Iterations	500.
Minimum Normalized Density	1.e-003
Convergence Accuracy	0.1 %
Penalty Factor (Stiffness)	3.
Region of Manufacturing Constraint	Include Exclusions
Region of Min Member Size	Exclude Exclusions
Region of AM Overhang Constraint	Exclude Exclusions
Solver Controls	
Solver Type	Program Controlled
Output Controls	
Analysis Data Management	

Optimization Settings

Objective

Right click on the grid to add, modify and delete a row.

Enabled	Response Type	Goal	Criterion	Formulation	Environment Name	Weight	Multiple Sets
☑	Compliance	Minimize	N/A	Program Controlled	Static Structural	N/A	Enabled

Objective

Scope	
Scoping Method	Optimization Region
Optimization Region Selection	Optimization Region
Definition	
Type	Response Constraint
Response	Mass
Define By	Constant
Percent to Retain	50 %
Suppressed	No

Scope of Mass Constraint

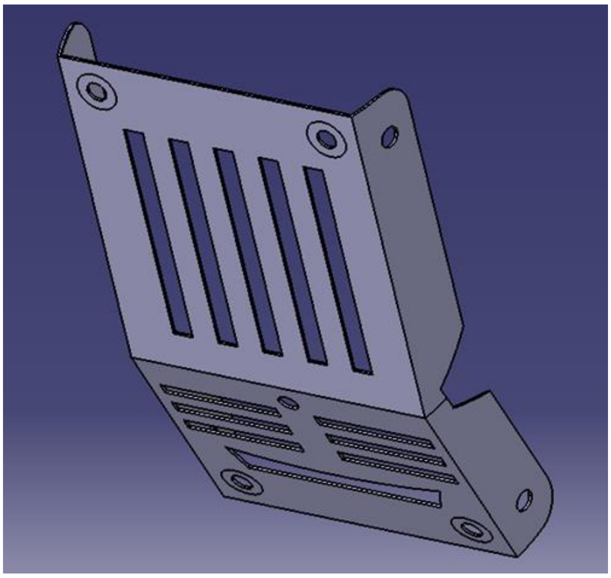


Figure – Optimized Design

3.1. Static Analysis Results – Optimized Design with ASTM A36 HR material

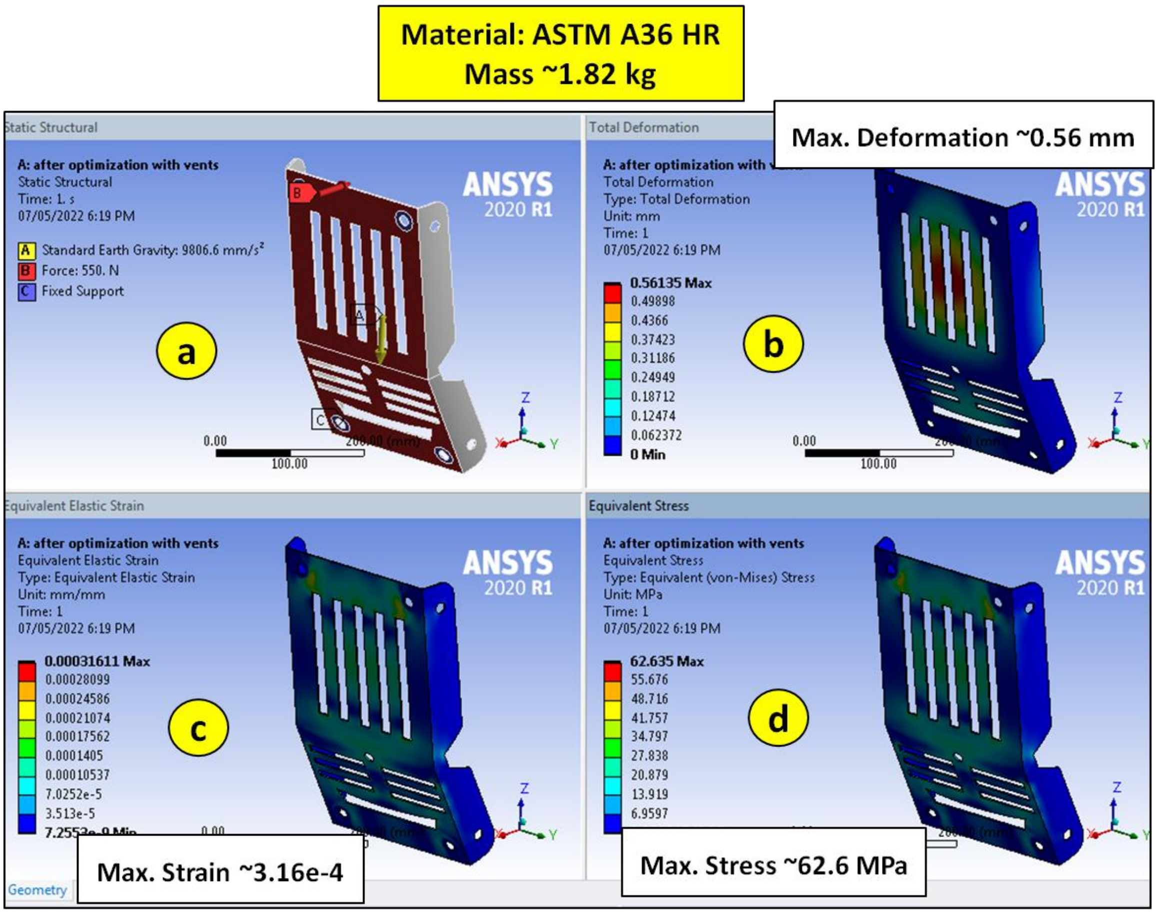


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

Iterations Using Different Materials and Result Comparison

The optimized design of engine cover is analyzed for below different materials and their results are compared.

a) Steel 4043
b) Aluminum 6061 T6
c) Poly vinyl chloride (PVC)
d) High density polyethylene (HDPE)
e) PP GF30

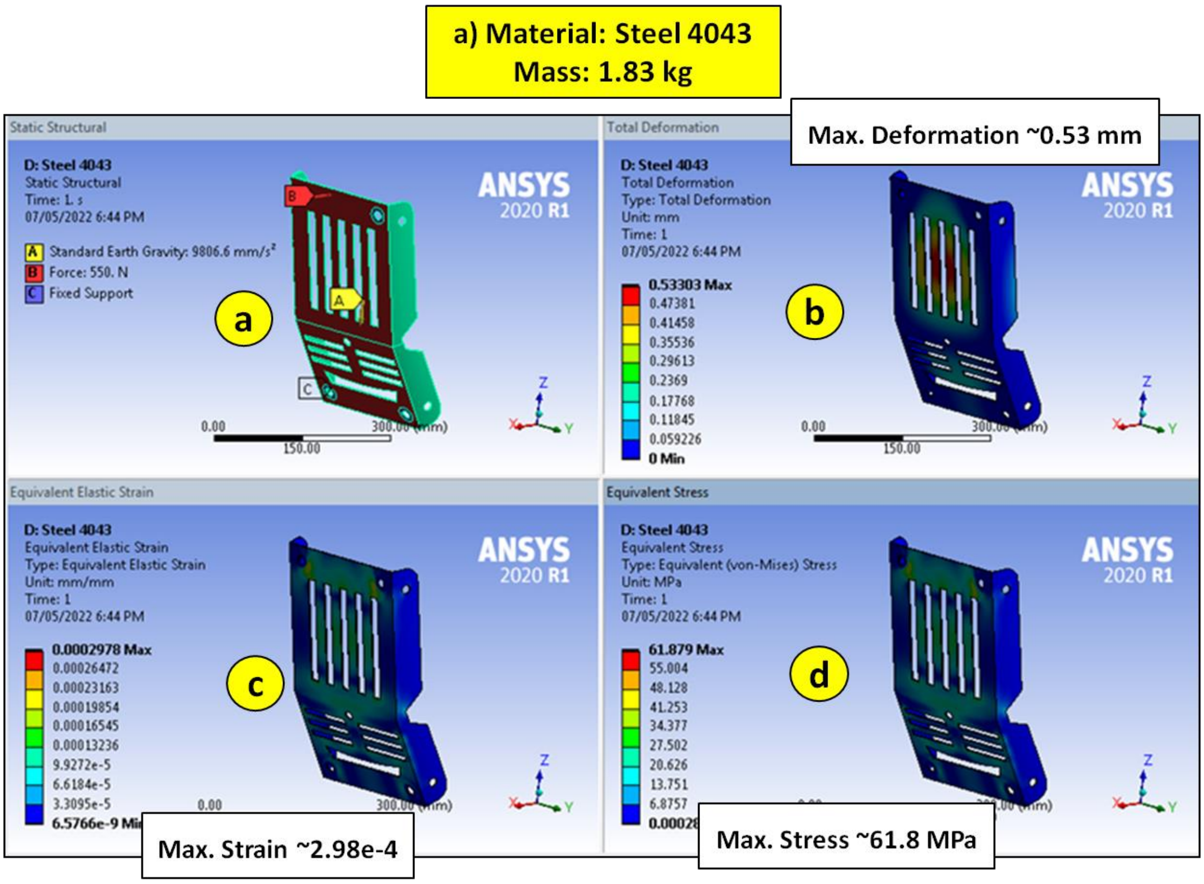


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

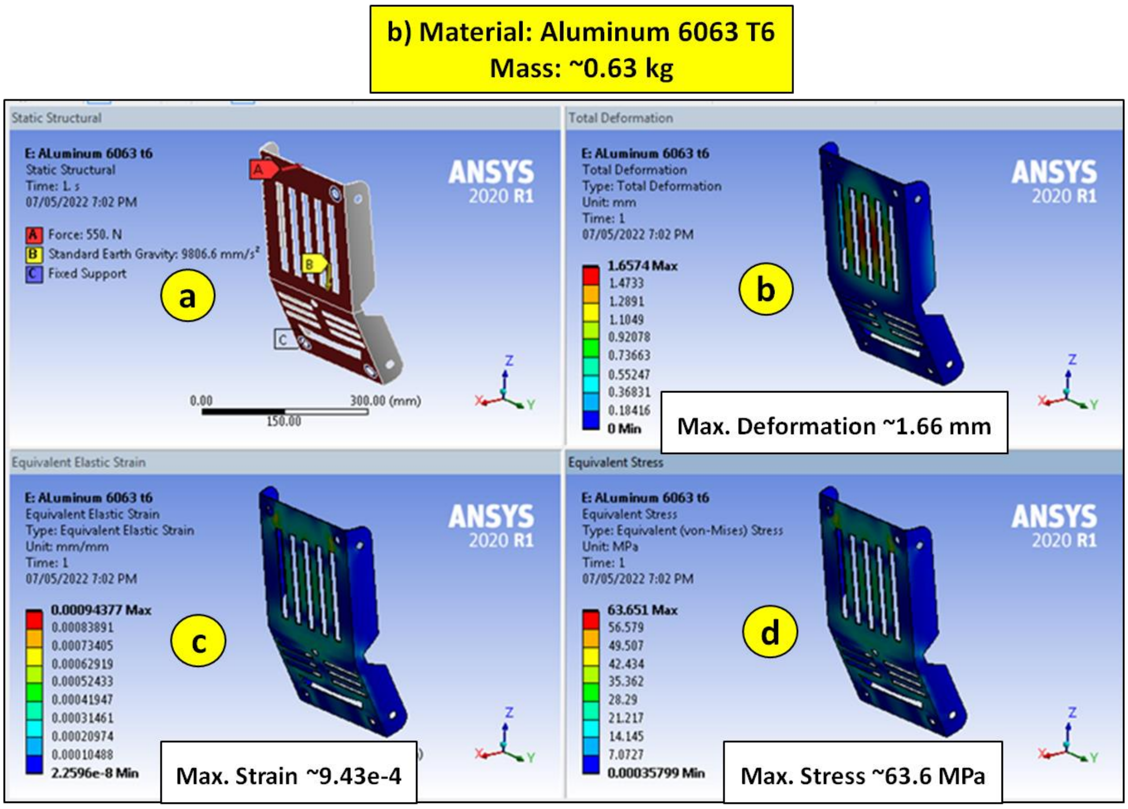
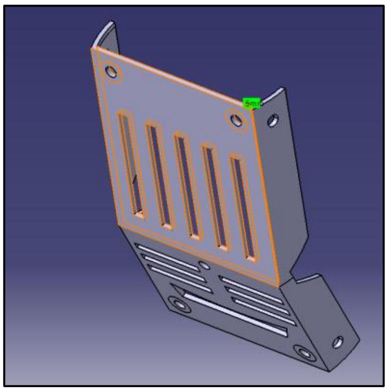


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

3.1.1. Static Analysis Results–Optimized Design–Iteration-3



- Due to manufacturing constraints, thickness for plastic or polymer parts needs to be increased. It cannot be manufactured in lower thicknesses like steels or metals.
- Taking this into consideration engine cover thickness has been increased from 2.0 mm to 6.0 mm when analyzing with plastics.

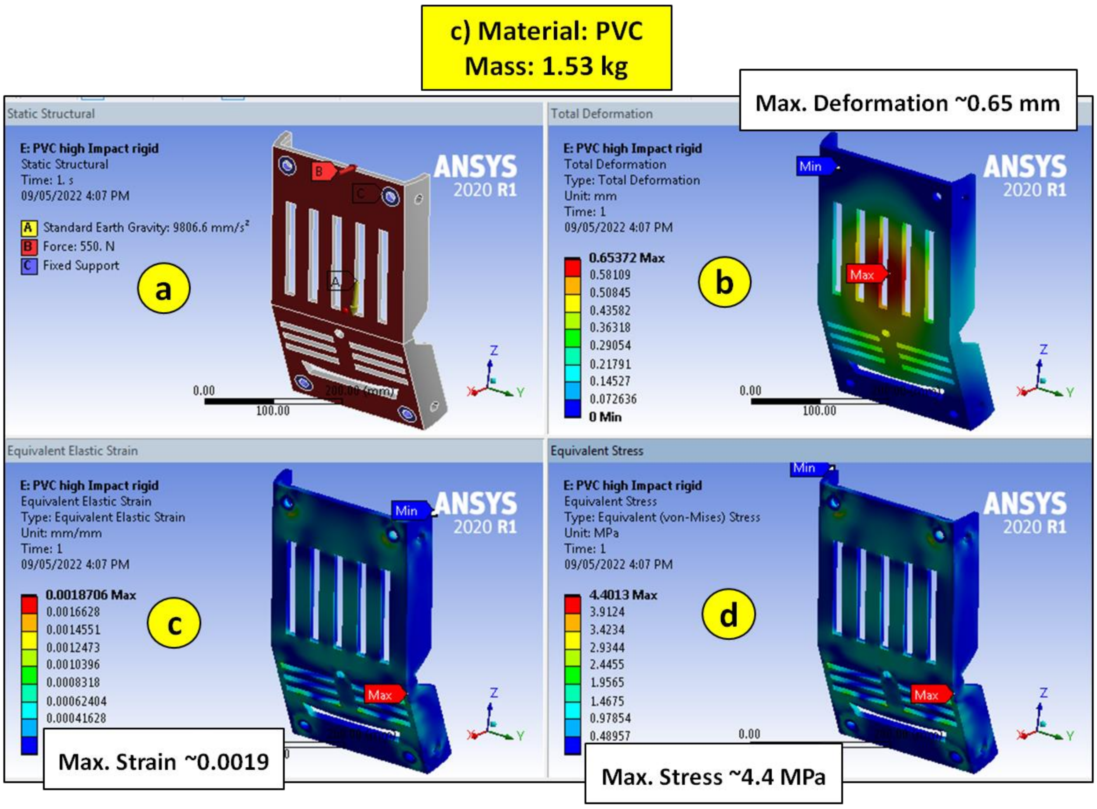


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

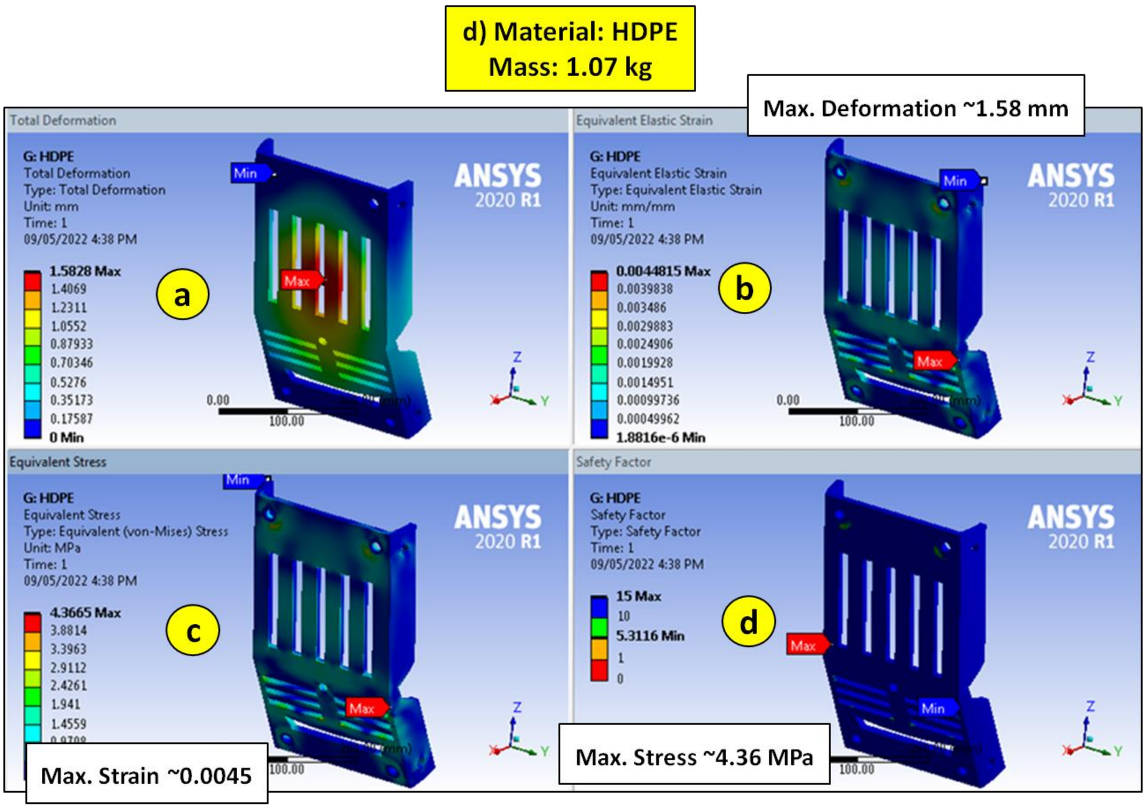


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

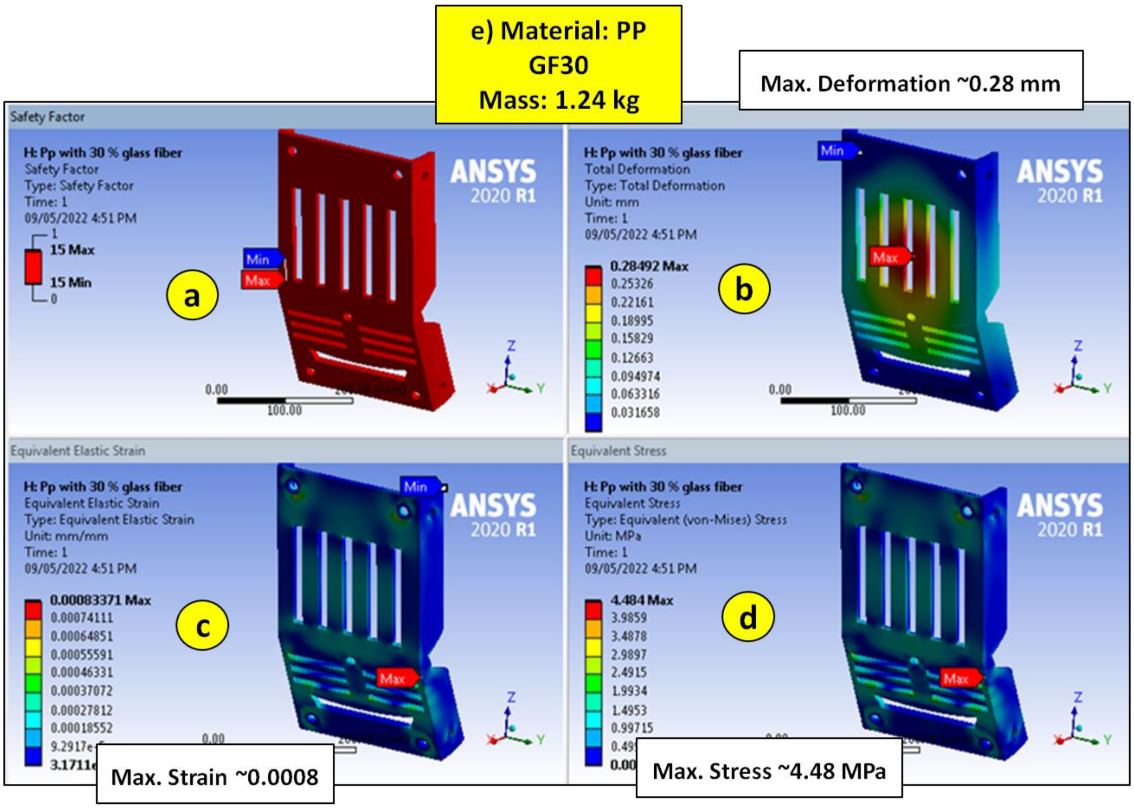


Figure – Results a) Boundary condition b) Total deformation c) Strain d) Stress

4. EXPERIMENTAL TESTING

- The designed part with derived condition has been produced with the help of additive manufacturing process of laser cutting and CNC bending machine.
- Produced part is tested with the Universal Testing Machine for a compressive force of 550 N.

Universal Testing Machine

- Universal testing machines are used to determine the physical and mechanical properties of raw materials and components by measuring and analyzing their performance under varying tensile or compressive forces, in numerous test methods.
- The "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials, components, and structures.
- A universal testing machine consists of two main parts-
    - Loading Unit
    - Control Unit

- The arrangement of the test specimen and the exertion of the load is held in the loading unit. The variations in the application of the load and the corresponding test result are obtained from the control unit.
- In the figure, the left unit with table and crosshead form the loading unit. The right unit with a load indicator arrangement is the control unit.

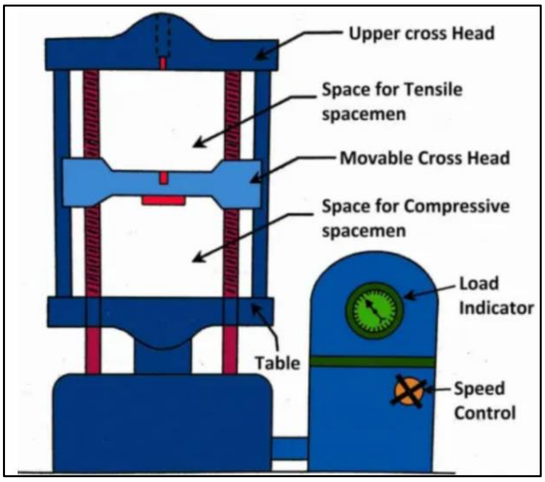


Figure – Components of UTM

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Figure – Experimental Testing of Engine Cover

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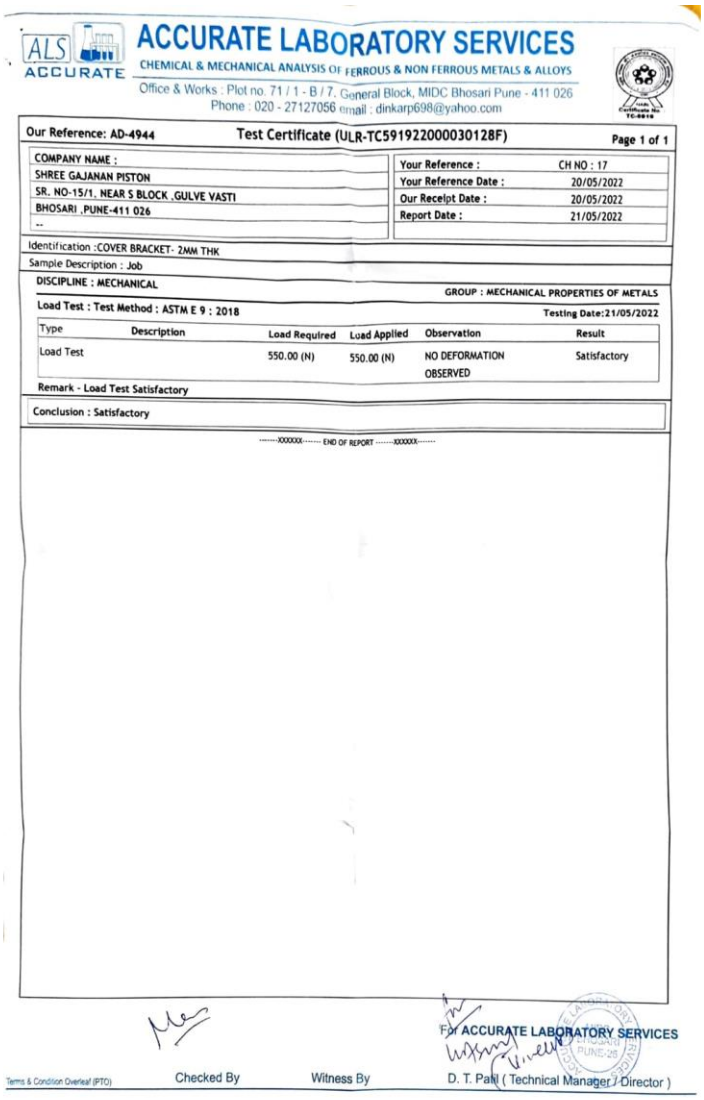
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Our Reference: AD-4944 Test Certificate (ULR-TC591922000030128F) Page 1 of 1

COMPANY NAME :	Your Reference : CH NO : 17
SHREE GAJANAN PISTON	Your Reference Date : 20/05/2022
SR. NO-15/1, NEAR S BLOCK ,GULVE VASTI	Our Receipt Date : 20/05/2022
BHOSARI ,PUNE-411 026	Report Date : 21/05/2022
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Identification :COVER BRACKET- 2MM THK
Sample Description : Job

DISCIPLINE : MECHANICAL
GROUP : MECHANICAL PROPERTIES OF METALS

Load Test : Test Method : ASTM E 9 : 2018
Testing Date:21/05/2022

Type	Description	Load Required	Load Applied	Observation	Result
Load Test		550.00 (N)	550.00 (N)	NO DEFORMATION OBSERVED	Satisfactory

Remark - Load Test Satisfactory

Conclusion : Satisfactory

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Figure – Experimental Testing Report

- Optimized part of material Steel 4043 is tested with the Universal Testing Machine for a compressive force of 550 N.
- After testing, it is evident that, optimized part with Steel 4043 material does not have considerable deformations.
- The performance of part is satisfactory under given loading conditions.

5. CONCLUSION

An investigation of this kind requiring extensive FEA and is naturally limited in a restrained time frame to prove several features of scientific interest in depth. It is considered that future work in this area of research should attempt to quantify other factors and experimental work.

FEA Static Structural Analysis had been successfully conducted on the Engine Cover for the given load condition, to investigate the deformation, stress & vibrational modes of frequency for a defined boundary condition. Finally, results were observed and are as follows.

Iteration 1 –

In 1st iteration part body was designed for 2.0 mm thickness, stress factors on cover was negligible so, in order to minimize the material condition topology was conducted in iteration 2.

Iteration 2 –

Topology was conducted to minimize material from the proposed part body. The iteration was set for 500 iteration step process and 50 % mass retention scope setting was made. In this iteration mass of cover is as below-

Before Topology Optimization	= 2.144 Kg
After Topology Optimization	= 1.821Kg

Iteration 3 –

In this iteration five different types of materials were compared among metal alloys & polymers with composite

- Steel 4043 is best among the alloys if we go across the strength.
- Aluminium 6061 T6 has lesser mass than any other material solved for the part body, but because of aluminium elastic absorption property the deformation is 1.176 mm with a stress of 63.65 MPa.
- Three Polymers (PVC, HDPE & PP GF30) are analyzed in it. For polymer material, the thickness of engine cover must be modified. Refer following table for the results of iterations solved in this project.

5.1 Result Summary Table

Sr. No	Material	Iteration Type	Total Deformation in mm	Strain	Stress in MPa	Mass in Kg
1	Structural steel	Static Structural	0.19254	1.819e-4	36.189	2.1441
2	Structural steel	Topology Optimization	0.56135	0.000316	62.635	1.821
3.	Steel 4043	Static Structural	0.53303	0.000297	61.879	1.831
4	Aluminum 6061 T6	Static Structural	1.657	0.000943	63.651	0.6270
5	PVC	Static Structural	0.65372	0.00187	4.4	1.5314
6	HDPE	Static Structural	1.5828	0.004481	4.365	1.0693
7	PP GF30	Static Structural	0.2849	0.000833	4.484	1.2423

Table – Result Summary

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