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Design & Analysis of Engine Mount Bracket by Varying Weld Bead Size

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Abstract:

Fatigue damage assessment is very important in design process of component to determine their durability under service loading conditions. In service, the great majority of structures and components are subjected to stress of variable amplitude loading. The purpose of this project is to analyses statistically deformation, strain & stress concentration factors during cyclic loading and compare their effect on fatigue damage of the engine mount bracket. Meanwhile, damage of the engine mount bracket was evaluated using finite element commercial software. From the analysis, we had observed that the fatigue damage Increases with the respective statistical values of the boundary condition and also it can reduce with increase in the weld bead to achieve more strength

Keywords: Static structural analysis, FEA solver, ANSYS workbench, Vibrational Investigation, & Topology optimization.

INTRODUCTION :

The need for light weight structural materials in automotive applications is increasing as the pressure for improvement in emissions and fuel economy increases. Most effective way of increasing automobile mileage while decreasing emissions is to reduce vehicle weight. The incorporation of aluminum and magnesium alloys into automotive structures has steadily increased to meet all these requirements. At present the average use of aluminum per vehicle is of 87 kilograms as per the study.

The strategy of increasing use of light alloy content in vehicle has proven to be a successful method of achieving fuel efficiency and environmental concerns. The strong emphasis on the cost has demanded the component manufacturers to improve the performance of their materials and to find the methods to deliver these materials at reduced cost.

Following Design considerations are taken into account : Engine Vibration, Misalignment, Engine Damage.

PROBLEM STATEMENT :

So, our scopes over analysis of engine mounting bracket for safety consideration of the vehicle. The objective of this work is to newly design an existing component and compare out best material and most suitable design assembly with the constraints of maximum shear stress, equivalent stress and deflection of the bracket under boundary load condition. The problem to be dealt with for this work is that, the mounting bracket thickness should be optimized for its minimum weight and also be taken care that stress should be below yield stresses. In India with 24 hours of running vehicles with uneven and worst road conditions due to which there are always possibilities of being failure/fracture in the mounting bracket. Therefore, brackets with high strength cross section are needed to minimize the failures including factor of safety in design. Hence our project helps in identifying the strength of an engine mounting bracket under varying boundary condition and material sustainability, also vibrational model analysis for bad road conditions.

OBJECTIVES :

1. To check the fatigue factors of mount bracket for engine carrying load while moving condition and also to check its life, damage, Safety factors and biaxiality induction of nominal stress value.
2. To optimize the bracket using topology companion density based in order to reduce the usage of material in manufacturing it.
3. To make sure that the bracket sustains all the natural force evacuated while in vehicle moving condition.
4. To isolate the vibrations produced during damping on irregular road terrain.

DESIGN SPECIFICATIONS :

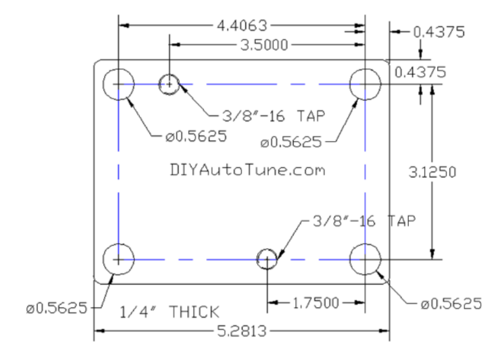

Fig. 1 Design Specification (Base Plate)

Thickness = 6.35 mm

Holes diameter = 14.2875 mm = 4X corner side

Tap diameter = 9.525 mm = 2X

Hole center distance vertica l= 79.375 mm

Hole center distance horizontal = 111.92002 mm

Upper Tap distance from right datum horizontal = 88.9 mm

Lower tap distance from right datum horizontal = 44.45 mm

Total horizontal width =134.14502 mm

Total vertical width=101.6 mm

Hole vertical distance from upper datum =11.1125 mm

Hole horizontal distance from right datum = 11.1125 mm

Weld plat dimensions :

Hole dimeter= 14.2875mm = 2X

Vertical distance from bottom plate centric aligned = 2= 64.95 mm

Metric hex bolts, Zinc plated class 8.8 steel, 14mm x 2.0mm x 130mm

A. Weld specification :

Limits

1^{st} =3mm

2^{nd}=3mm

Height (c) =2.5mm flat

Offset =0.5mm

B. Loading Condition

Chevy V6-60 2.8, 3.1 =350 pounds = 1560 N

The average weight of a 4-cylinder modern aluminum car engine is 200 to 350 pounds (90 to 160 kg), quite much lighter than a v6 or v8 engine. If it's a cast-iron block you can expect it to be slightly heavier than an aluminum engine.

Total Mass = weight of the engine * FOS + self-payload

Designer FOs = 1.5

Self-pay load = 2-3Kg = 30 N

Total Mass = 2370N

No of bracket = 2

Final Mass on one bracket = total mass/no of brackets = 2370N

design is made using Catia software and Structural analysis is done using ANSYS Workbench

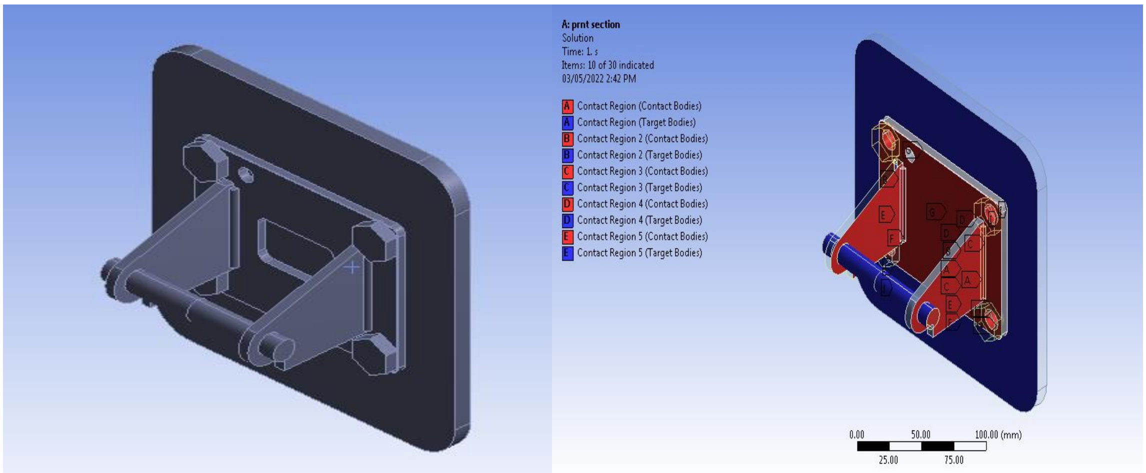

Fig. 2 Contact regions

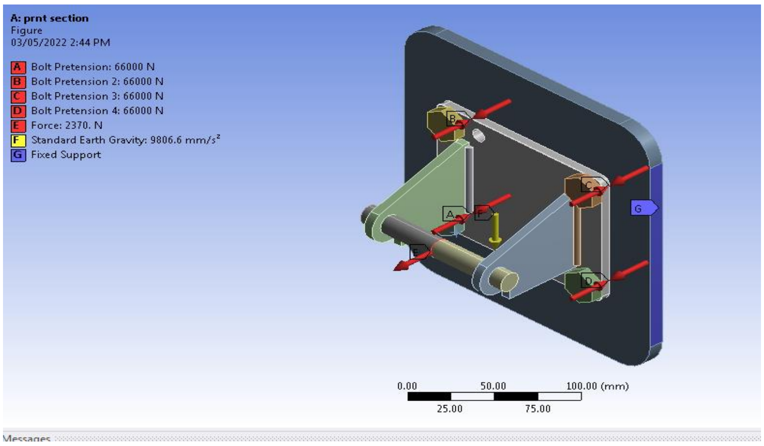

Fig.3 Boundary Conditions

RESULTS

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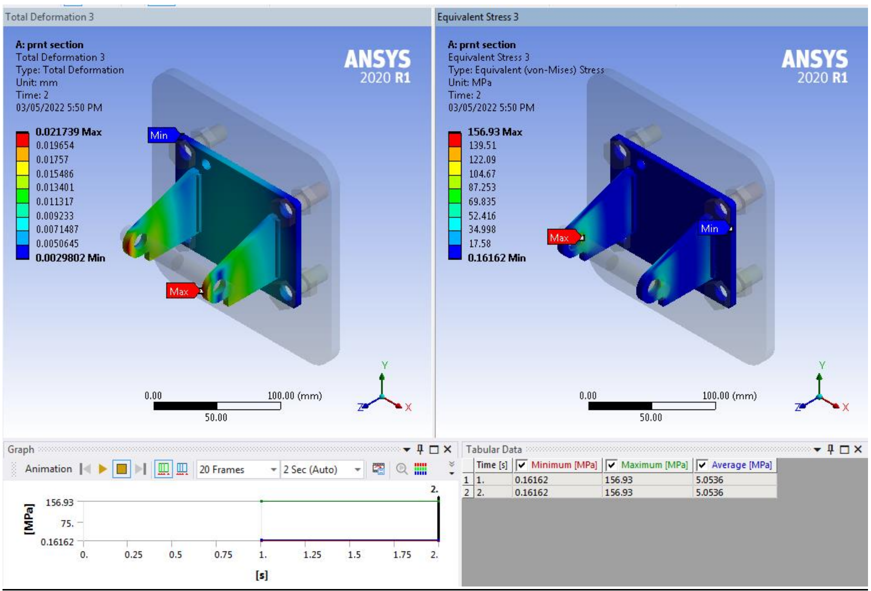


Fig. 4 Deformation & stress factors only on bracket

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.			
2.			

Table. 1Total deformation of bracket

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.			

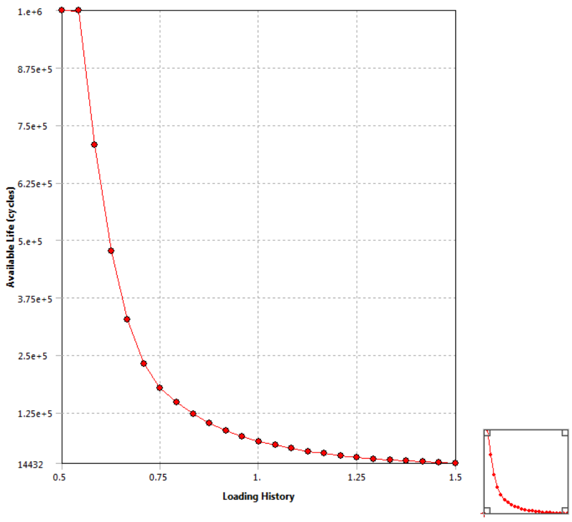
Table. 2 Stress factor

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	9.2743e-002		
2.	9.2741e-002		

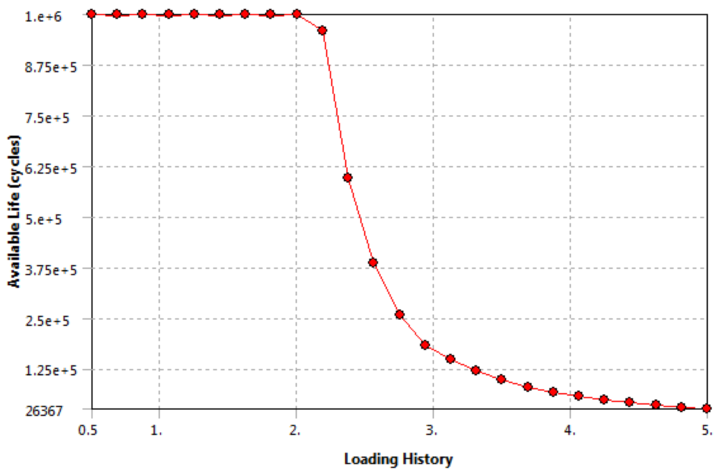
Table. 3 Local Von-Miss Stress from Min to max

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.			
2.			

Table. 4 deformation at weld area



Graph. 1 Fatigue Sensitivity chart of bracket



Graph. 2 Fatigue Sensitivity chart of Weld

C. SN-Curve

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0

214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

Table. 5 S-N curve

D. Second Iteration Strategy (Topology Optimization) :

Redesigned part with minimized material condition & equalized strength condition.

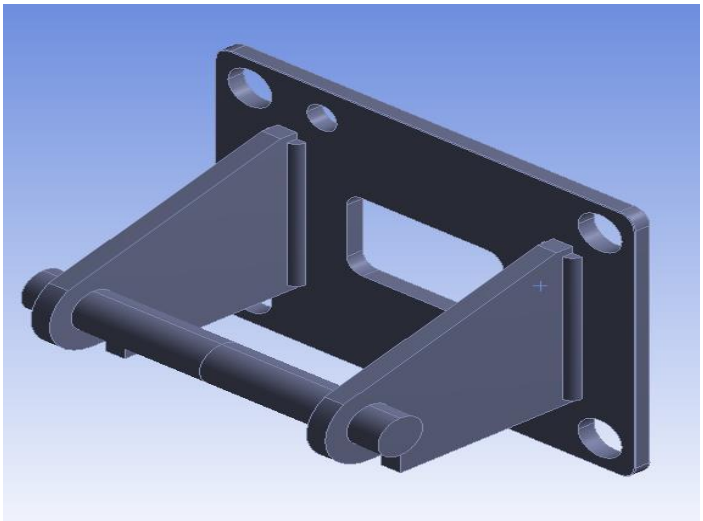


Fig. 5 Redesigned part

Boundary conditions and mesh configuration has been kept constant throughout the solution, only material & design has been changed.

In this iteration modification in design has been made to reduce the Material mass while manufacturing it.

Comparison of After weld bead change, from 3mm to 5 mm throat or fillet thickness.

EXPERIMENTATION & VALIDATION

Experimental testing

The designed part with lower weight condition has been fabricated with the help of additive manufacturing process of laser cutting, drilling & finish machining.

Fabricated part is tested with the universal testing machine for a compressive force of 2370 N. & the results are as followed.

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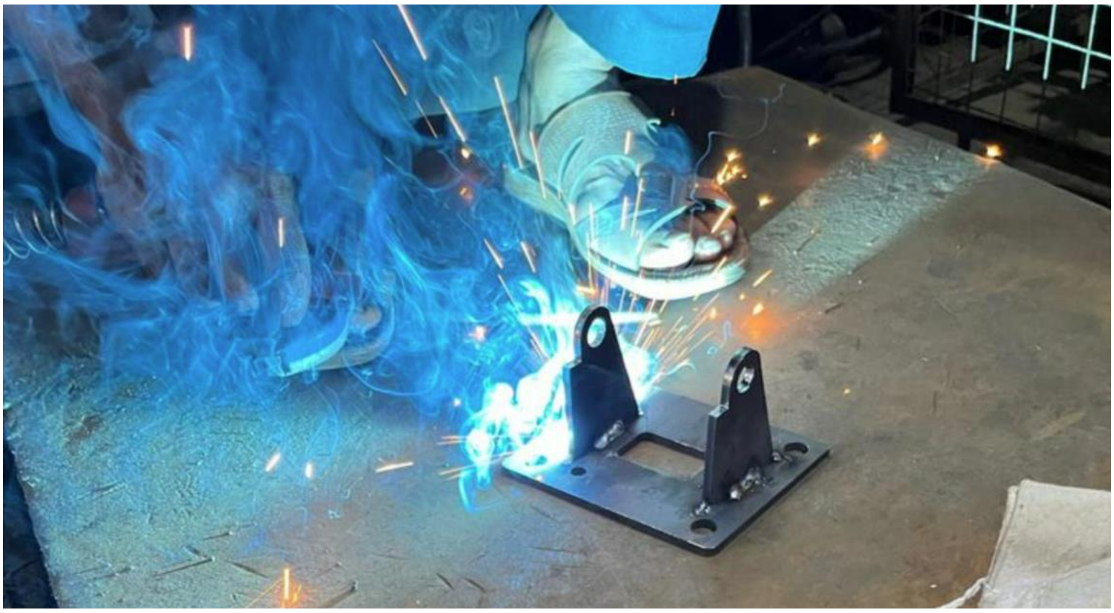

Fig.6 Preparation

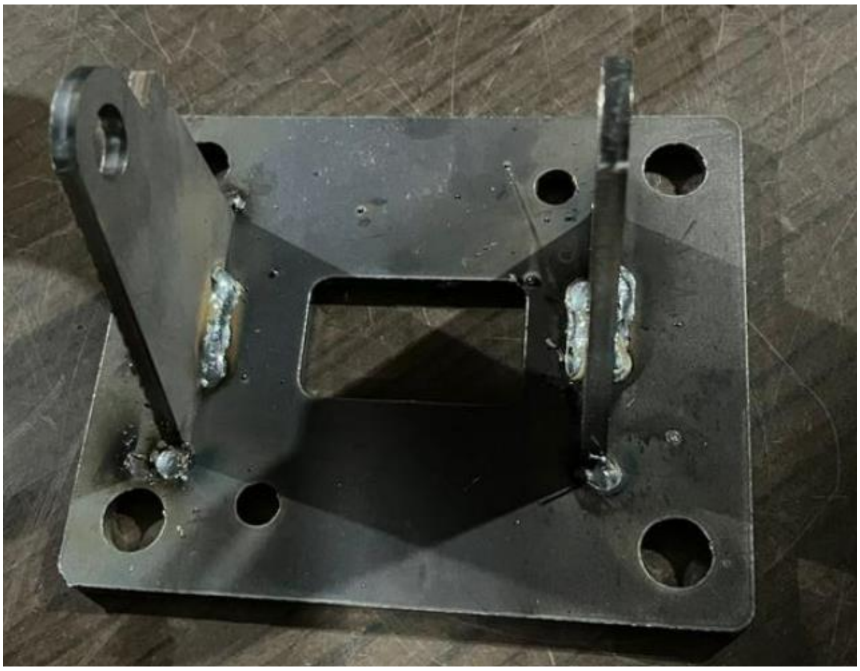

Fig. 7 Final Part

Testing :

Loading condition = 2370 N compressive in vertical Z-Direction

Fixture Base plate end face =1 face

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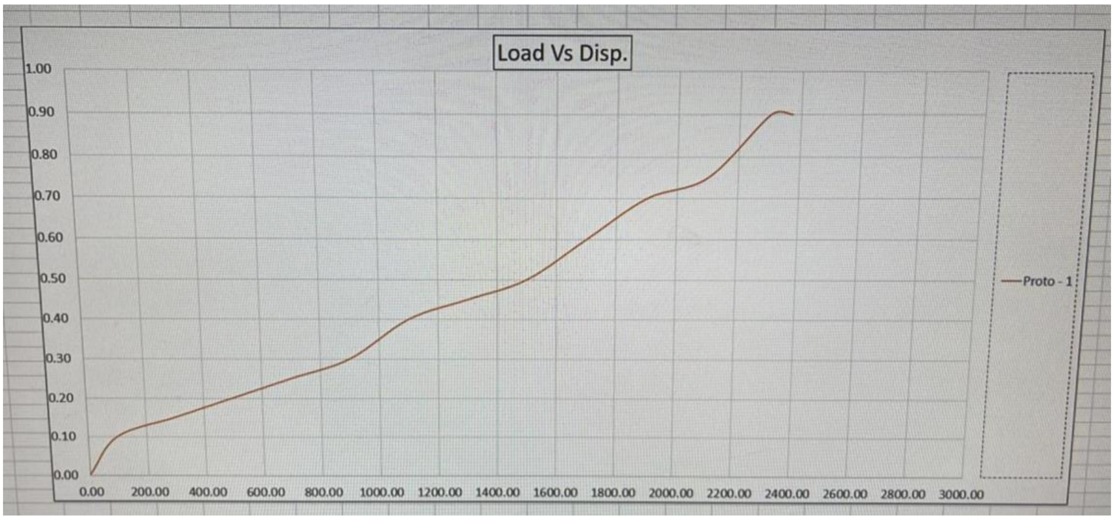
Fig. 8 UTM testing on Proposed part Fig Compressive load

Deflection Observed on the part body via digital meter of UTM = 0.9 mm Deflection from its original form.



Graph.3 Load vs Deflection experimental reading

Software results

Deformation observed on the pin = 0.876 mm

Stress on the pin = 267.67 Mpa

Deformation on the bracket = 0.1289 mm

Stress on the bracket = 267.37 Mpa

$$\text{Error} = \frac{0.876*100}{0.9} = 2.67\ \%\ \text{error}$$

Hence 4 % of error is negligible

CONCLUSION

FEA Static Structural Analysis had been successfully conducted on the Engine Mount bracket for the self-load condition, to investigate the stress concentration factor & vibrational modes of frequency for a defined boundary condition. Finally, all the results were observed and noted down.

In first iteration the proposed modal was solved for the Static condition, stress and deformation factors were more so on the bracket for a applied boundary Condition, so optimization strategy was used to reduce the material mass and also to maintain equalized strength.

After 1st optimization redesign was made, by removing the material and then solved for the same. This time deformation and stress factor were brought to minimum by conducting topology method.

2nd optimization Another attempt is made to reduce some more material form the part body but stress factor was induced to the high functionality. So, weld bead was increased from 3mm thickness to 5mm. hence the part body brought to minimum condition.

Material Comparison For final designed part of bracket Material comparison was Made to investigate the stress factors for Aluminum 3003 & Magnesium Alloy, for a lower weight condition. Hence the solution was optimum as expected.

The following result table explains the FEA modulation for designed, optimized part of engine mount bracket.

VALIDATION

The proposed part body with minimized weight condition has been successfully fabricated with the additive manufacturing process. Then the part body was fixed on the UTM machine vertically, fixing the bottom base end surface as fixed support and a vertical downward or compressive force is applied and results were noted.

The work part has an deflection of 0.9 mm on the pin when tested on machine and 0.876 mm deflection in the software.

Hence the bracket has lesser deformation as per the data loaded in the FEA software hence the parameter with the proposed design is suitable to handle the engine weight with minimized weight condition.

From the above observation table one can conclude that, if the part body has a much larger volume with mass, then the body part mass can be reduced by increasing the weld thickness to rigidly hold the bracket under external loading condition.

Form the above FEA solution Aluminum & Magnesium Material are showing better results with minimum weight condition and stress concentration factors are lower. Welding Magnesium can affect in cost modulation while fabricating it, it will be better to take Aluminum 3003 material l for the bracket.

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