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Weight Reduction of Engine Mounting Bracket

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Abstract: Weight of an automobile and its parts are an important parameter regarding its performance and efficiency. As the weight of vehicle increases its fuel efficiency and performance decreases. To enhance the performance of an automobile, the automobile parts should be lighter in weight and also possess the required strength. So, Weight reduction of engine mounting brackets can be achieved by changing the material of brackets and also by optimizing the material removal for hole manufacturing on the brackets. Optimization of material removal rate is done by applying Taguchi method. Under this project, study of optimization of material removal rate will be done by using Taguchi method and signal-to-noise ratio graph will be obtained with the help of Minitab Software. In this automotive era the need for light weight structural materials is increasing as there is a more focus on fuel consumption reduction and improvement in decreasing the emission. The magnitude of production volumes has traditionally placed severe requirements on the robustness of process used in the manufacturing. The manufacturers have strong importance on the cost has the demand for the component to improve the material performance and to deliver these materials at low cost is the requirement. The result & conclusion will be drawn and suitable future scope will be suggested.

Keywords: Engine Mounting Bracket, Taguchi, Minitab, Result

1. Introduction

In this automotive era the need for light weight structural materials is increasing as there is a more focus on fuel consumption reduction and improvement in decreasing the emission. The magnitude of production volumes has traditionally placed severe requirements on the robustness of process used in the manufacturing. The manufacturers have strong importance on the cost has the demand for the component to improve the material performance and to deliver these materials at low cost is the requirement.

"An automotive engine-body-chassis is typically subjected to unbalanced engine forces, uneven firing forces especially at the idling speeds, shaking forces and torques due to reciprocating parts, dynamic excitations from gearboxes, accessories and road excitation [1, 2]."

In automobile sector the extremely competitive automotive business needs manufactures to pay a lot of attention to traveling comfort. Resonant vibration is from unbalanced masses exist within the engine body, this is causing the designers to direct their attention to the event of top quality engine mounting brackets so as to confirm that there is improvement in riding comfort. The demand for higher play acting engine mount brackets should not be offset by arise within the production prices and/or development cycle time.

In diesel engine, the engine mounting bracket is the major problem as there is un-throttled condition and higher compression ratio and even there are more speed irregularities at low speed and low load when compared to gasoline engines. So due to this there are more vibration excitation. By this vibration engine mount bracket may fail, so by optimizing the shape and thickness of engine mount bracket we can improve the performance at initial design stages. By some studies it is observed that brackets saved 38% of mass. Structural optimization is an important tool for an optimum design; comparison in terms of weight and component performance structural optimization techniques is effective tool to produce higher quality products at lower cost.

OPTIMIZATION:

Optimization is an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible. It is the act of obtaining the best result under given circumstances. The word 'optimum' is taken to mean 'maximum' or 'minimum' depending on circumstances. In design, construction, and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. Since the effort required or the benefit desired in any practical situation can be defined as the process of finding the conditions that give the maximum or minimum value of a function.

"Shape optimization method is usually applied to the topology optimised design for further mass reduction while the required strength character is maintained [3]."

There are four methods of optimization such as:

a) Fuzzy Logic.
b) Taguchi Method.
c) RSM Method.
d) DOE Method.

TAGUCHI METHOD

Genichi Taguchi is the name of a Japanese engineer who has been active in the improvement of Japan's industrial products and processes since the late 1940s, after the Second World War. Taguchi's major contribution has involved combining engineering and statistical methods to achieve rapid improvements in cost and quality by optimizing product design and manufacturing processes. Taguchi methods represent a new philosophy in which quality is measured by the deviation of a functional characteristic from its target value.

"The Taguchi method uses the signal-to-noise (S/N) ration instead of the average to convert the trial result data into a value for the characteristic in the optimum setting analysis"

Engine Mounting Bracket

Engine mounts themselves are small parts that are meant to stabilize, as well as properly align, a vehicle's engine. So, even though these mounts are small, they play a large role in the overall functionality of the heart of your vehicle.

"The engine mount assembly includes a support member arranged to be attached to a vehicle frame component [4, 5]".

2. Objectives

a) To reduce the weight of conventional engine brackets by redesigning it and create a CAD model of engine brackets & to performing static structural analysis of redesigned engine brackets.
b) To apply Taguchi method for manufacturing of mounting holes on engine brackets.
c) To study the response variation by using the signal-to-noise ratio.
d) To plot signal-to-noise ratio graph by using MINI TAB software.
e) To obtain an optimum value of material removal rate (MRR) by using taguchi method.

3. Problem Statement

a) Weight of an automobile and its parts is an important parameter regarding its performance and efficiency.
b) Weight reduction of engine mounting brackets can be achieved by changing the material of brackets and also by optimizing the material removal for hole manufacturing on the brackets.
c) As the weight of vehicle increases its flues efficiency and performance decreases.
d) To enhance the performance of an automobile, the automobile parts should be lighter in weight and also posses the required strength.

4. Methodology

Step 1: I have started the work of this project with literature survey. Than have gathered as many research papers which are relevant to this topic. After going through these papers I have learnt about Analysis and optimization of engine brackets and manufacturing and mounting holes using Taguchi method.

Step2: After that the components which are required for my project are decided.

Step 3: After deciding the components, the 3 D Model and drafting is prepared with the help of CATIA software.

Step 4: The Analysis of the components would be carried on with the help of ANSYS using FEA. [6]

Step 5: The optimization of engine mounting brackets would be done with the help of Taguchi method.

Step 6: Result & Conclusion would be drawn after the analysis and the optimization.

5. Design

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design.

"Durability and reliability of a product are equally important from a customer point of view. [7, 8]"

CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

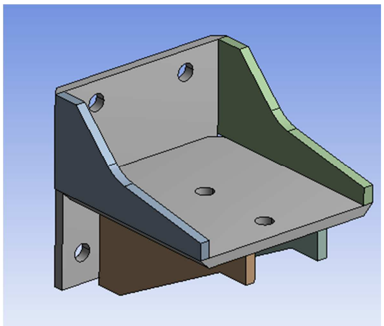


Figure 1. *CATIA model of Engine Mounting Bracket.*

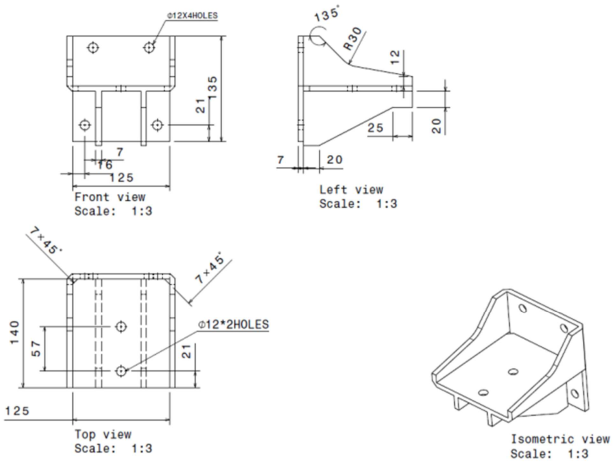
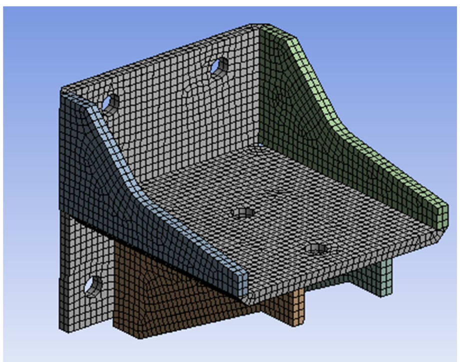


Figure 2. *drafting of set up.*

6. Analysis

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.

"This mesh can be generated directly from a solid model for the detailed part model designed in a three-dimensional (3D) CAD system [9]".



Statistics	
Nodes	49490
Elements	11516

Figure 3. *Meshing of model.*

Boundary Conditions

Loading

Loads: Specific values of load are implemented for a typical mounting bracket. The load is taken as 1000N. Load is applied at the two holes of the engine mounting bracket, which are connected to the engine structure with the help of rigid elements such as nut and bolts.

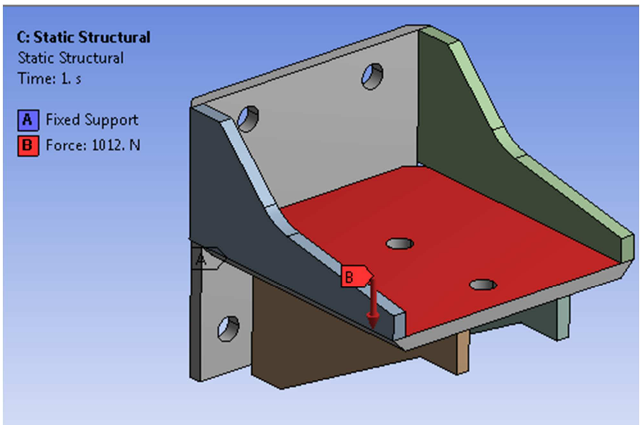


Figure 4. *Boundary Condition of model.*

Total Deformation

The total deformation & directional deformation are general terms in finite element methods irrespective of software being used. Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. Total deformation is the vector sums all directional displacements of the systems.

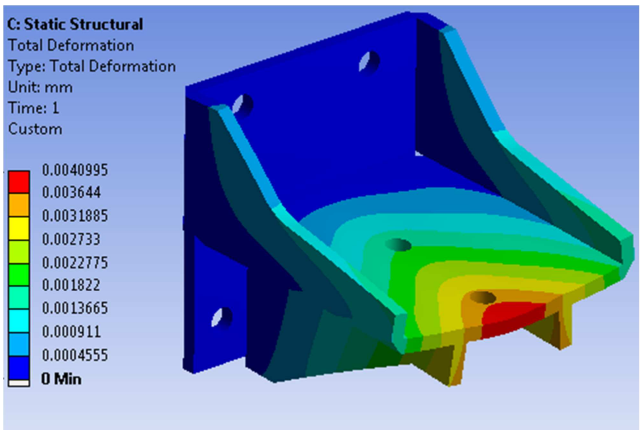


Figure 5. *Total Deformation of model.*

Equivalent Stress

Equivalent stress (also called von Mises stress) is often used in design work because it allows any arbitrary three-dimensional stress state to be represented as a single positive stress value. Equivalent stress is part of the maximum equivalent stress failure theory used to predict yielding in a ductile material.

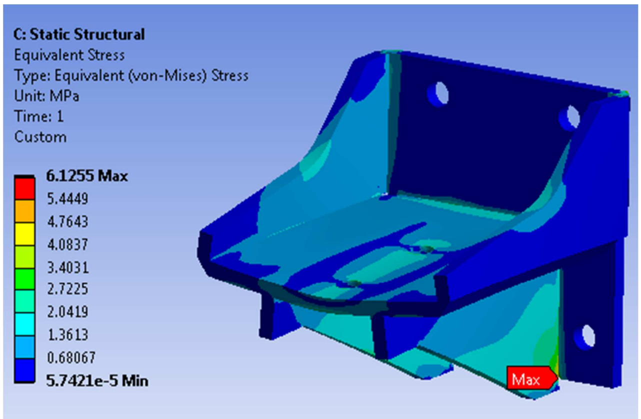


Figure 6. *Equivalent stress of model.*

TOPOLOGY OPTIMIZATION:

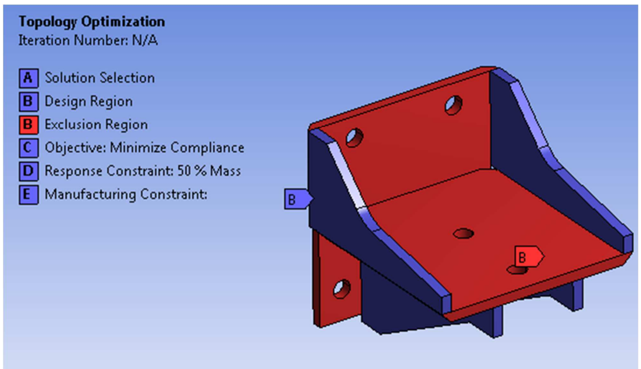
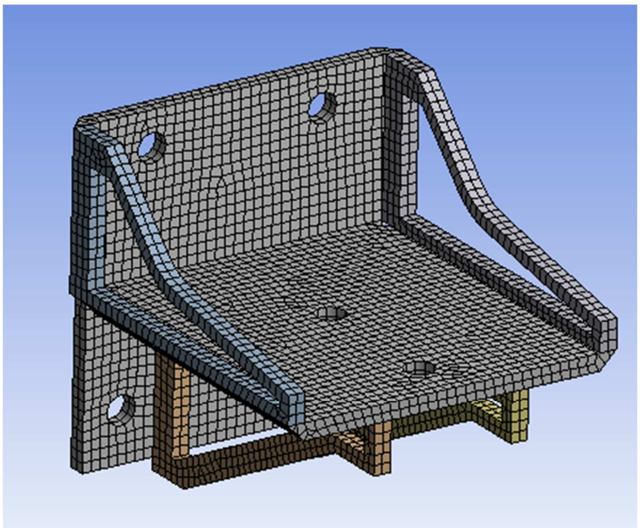


Figure 7. *Topology Optimization.*

Results obtained after Topology optimization

"The topology optimization is executed to remove the unnecessary material from the design space. [6]"



Statistics	
Nodes	42049
Elements	9095

Figure 8. *Meshing of optimized model.*

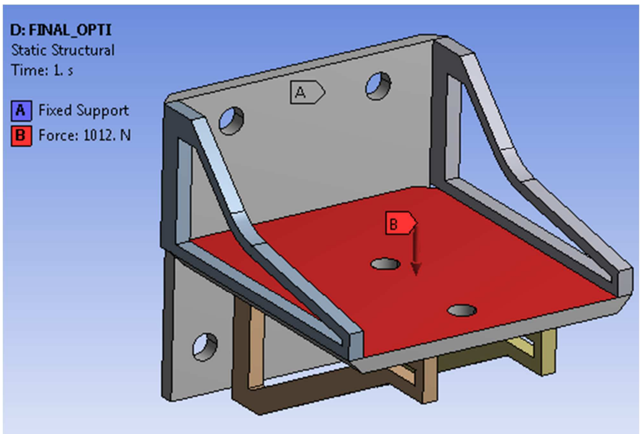


Figure 9. *Boundary Condition.*

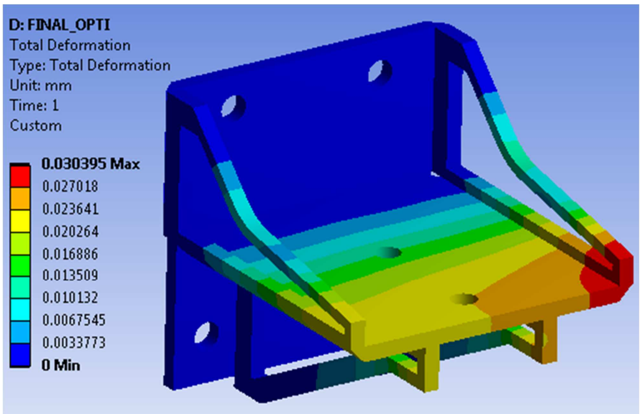


Figure 10. *Total Deformation of model.*

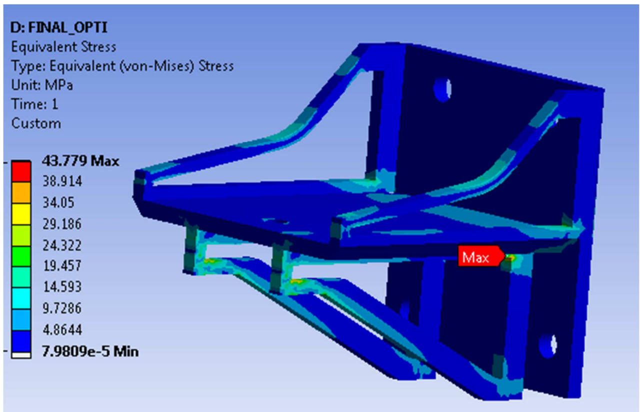


Figure 11. *Equivalent stress of model.*

EXPERIMENTAL TESTING:

The following Procedure were carried:

a) The plates are cut with the help of Laser Cutting.

b) The drilling operation on Engine mounting plate was carried on VMC machine.

c) The Speed, Feed & Depth of Cut Required for drilling operation were first decided.
d) I decided 3 speed, feed & depth of cut values.
e) After that the Orthogonal Array was formed with the help of MINITAB Software.
f) According to that Orthogonal Array, nine drilling Operations were carried out on VMC machine.
g) The Surface Hardness testing was carried out for all the specimens.
h) Then all the values of Surface roughness were put down in MINITAB software &Analysed the TAGUCHI design.
i) After getting the graph, the optimum Solution was drawn.

MINITAB RESULTS:

Before using Minitab, we need to choose Independent factors such as Speed, Feed & Depth of Cut for the inner array and Dependent factors such as Surface Roughness for the outer array. Independent factors are factors we can control to optimize the process. Dependent factors are factors that can affect the performance of a system but are not in control during the intended use of the product.

Worksheet 1 ***

↓	C1	C2	C3	C4
	SPEED	FEED	DEPTH OF CUT	Surface Roughness
1	80	0.100	0.5	1.74
2	80	0.050	1.0	2.50
3	80	0.012	1.5	1.33
4	160	0.100	1.0	0.67
5	160	0.050	1.5	1.79
6	160	0.012	0.5	2.14
7	660	0.100	1.5	1.34
8	660	0.050	0.5	2.43
9	660	0.012	1.0	2.41

Figure 12. *Orthogonal Array.*

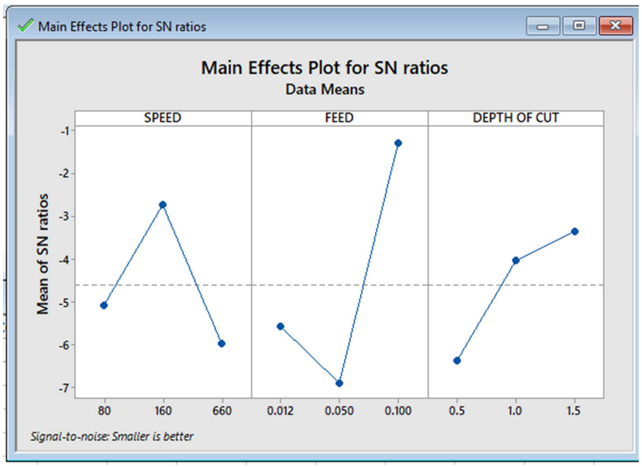


Figure 13. *Signal to Noise ratio graph obtained from MINITAB.*

"This analysis can be achieved by employing the S/N ratio to measure quality and orthogonal arrays and by simultaneously evaluating numerous parameters. [10, 11]"

7. Result and Conclusion

Table 1. *SN Graph*

SR. NO.	Characteristics	Bracket before optimization	Bracket after optimization
1.	Total Deformation (mm)	0.00409	+0.03059
2.	Equivalent Stress (MPa)	6.1255	43.779

From the SN Graph obtained from the MINITAB, the optimum solution is obtained. The main aim is to optimize the Drilling to get the minimum Surface Roughness.

The Solution obtained is Speed=160RPM, Feed=0.1 & Depth of Cut=1.5.

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