Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 3, No.3, March : 2025

VIBRATION ANALYSIS OF ENGINE MOUNTING BRACKET OF A CAR USING EXPERIMENTAL AND FINITE ELEMENT ANALYSIS

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ABSTRACT
The engine is a crucial component of a car, responsible for supporting the vehicle and mitigating vibrations caused by uneven road surfaces. Consequently, designing an appropriate engine mounting bracket is vital for automotive performance. When the natural frequency of the bracket coincides with the engine's excitation frequency, resonance can occur, potentially leading to bracket failure. To prevent this issue, it is important to increase the natural frequency of the bracket. To start, one must first ascertain the natural frequency of the existing engine mounting bracket. Following this assessment, modifications can be made to the dimensions of the bracket, and a new evaluation of its natural frequency must be conducted. This analysis should encompass six degrees of freedom, employing both finite element analysis and experimental methods to allow for a comprehensive comparison of the results from both techniques.
Keywords: Engine Mounting Bracket, Finite Element Analysis, Natural Frequency, FFT Analyzer.

I. INTRODUCTION
One of an automobile's most important parts is the engine. The Engine Mounting Bracket is a part that supports the engine in high-performance sports automobiles. This bracket is essential to improving the vehicle's overall working environment and level of comfort. Its main purpose is to reduce vibrations and support the engine. Fatigue brought on by sustained vibrations throughout the car may cause the bracket to fail if it persists. The engine and chassis are normally connected by three Engine Mounting Brackets. Each bracket has one end attached to the engine and the other to the body of the car. Through a bush that is fastened to the bracket, this design aids in the absorption of stresses and vibrations. The three Engine Mounting Brackets typically link the engine to the chassis. One end of each bracket is fastened to the car's body, and the other end is connected to the engine. This design helps absorb vibrations and strains using a bush that is attached to the bracket.

Cracks that start at high stress locations and spread throughout the bracket's structure are the main cause of the engine mounting bracket's failure. The vehicle's motion over uneven road surfaces and vibrations are the primary causes of these stresses.

II. LITERATURE REVIEW
Zhang Junhong et al. [1], The intrinsically complicated vibrational and acoustical activity of combustion engines has been studied by Zhang Junhong et al. [1]. This intricacy results from multiple parts that may function at a wide variety of speeds and encounter weights of different sizes. The creation of Computer-Aided Engineering (CAE) tools will boost production volume while also reducing the time needed to manufacture engines.

Gabriel-Petru ANTON et al. [2], By revising the engine's finite element analysis (FEA) model, Gabriel-Petru ANTON et al. [2] have examined the connection among Noise, Vibration, and Harshness test computations. They obtained absolute numbers for the vibration levels by concentrating on the vibrations levels in the lower and medium frequency regions. Both theoretical and experimental analysis were used in this study.

Senthilnathan Subbiah et al. [3], By creating durability testing on automobiles in actual settings, Senthilnathan Subbiah et al. [3] looked at ways to lower failures and warranty expenses for end users. Failure analysis of the three-wheeled vehicle muffler mounting brackets during the durability tests showed cracks at the welding locations between the brackets and the cradle, usually after an average of 10,000 kilometers. The finite element method, also known as FEM, was used for additional research. The combustion engine and muffler were treated as point masses in a model with finite elements that was developed for the engine's cradle assembly. The bracket acted as a cantilever beam, according to the design research, and changes were made to the design to remove the failures that were noticed.

Umesh S. Ghorpade [4], The combustion engine mounting bracket for an automobile was invented by Umesh S. Ghorpade [4], who concentrated on using three materials in its production: gray cast iron, magnesium alloy, and aluminum. He identified the engine mount bracket's natural frequencies during the model analysis. The gray cast-iron was discovered to have a low natural frequency, which would make it more difficult to control vibration in the engine mounting bracket. The Grey cast iron was therefore not taken into account. According to the investigation, magnesium and aluminum alloys both shown reduced stress levels and improved strength. Based on this investigation, magnesium alloy was ultimately chosen as the material of choice.

III. PROBLEM STATEMENT

The bracket that holds the engine in place is called the engine mounting bracket. If natural frequency of bracket becomes equal to excitation frequency of engine then it creates resonance which will cause failure of bracket. Also, the requirement of increase in mileage of cars is increasing day by day. There are 3 brackets which are connected to engine with one end and to chassis with other end. The operational life of Engine Mounting Bracket is 2 to 4 years according to it’s use. Due to high vibrations on uneven road surface cracks of failure of bracket occurs. As per data collected from Suzuki workshop, there are 30 cases of failure of bracket since the year 2020. Therefore, it is crucial to examine the Engine Mounting Bracket design.

IV. OBJECTIVES

1) To use an FFT analyzer and the Finite Element Analysis program Abaqus to perform a vibration analysis of the current engine mounting bracket.
2) To suggest a suitable dimensions for the Engine Mounting Bracket.
3) To conduct vibration analysis of the modified Engine Mounting Bracket using Finite Element Analysis software Abaqus and FFT Analyzer.
4) Comparing results between existing and modified bracket.
5) To study Von- misses stress, weight reduction and cost reduction of existing and modified Engine Mounting Bracket.

V. METHODOLOGY

First, prior study has demonstrated that an automobile's engine mounting bracket is an essential part. The Engine Mounting Bracket's design, operation, and application have all been the subject of a theoretical examination. The bush that is fastened to the bracket also contributes significantly to vibration absorption. According to the study, boosting the bracket's inherent frequency can aid in preventing resonance.

VI. ‘3D’ MODEL OF EXISTING AND MODIFIED ENGINE MOUNTING BRACKET

Figure 6.1: ‘3D’ Model and Drafted Image of Existing Engine Mounting Bracket

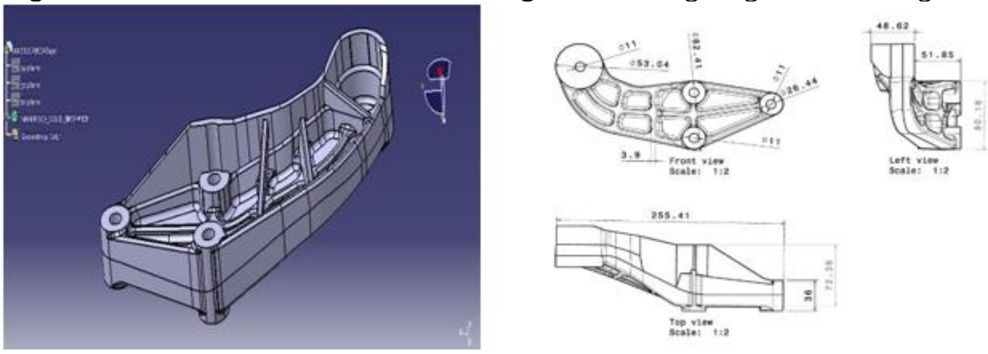

Figure 6.2: ‘3D’ Model and Drafted Image of Modified Engine Mounting Bracket

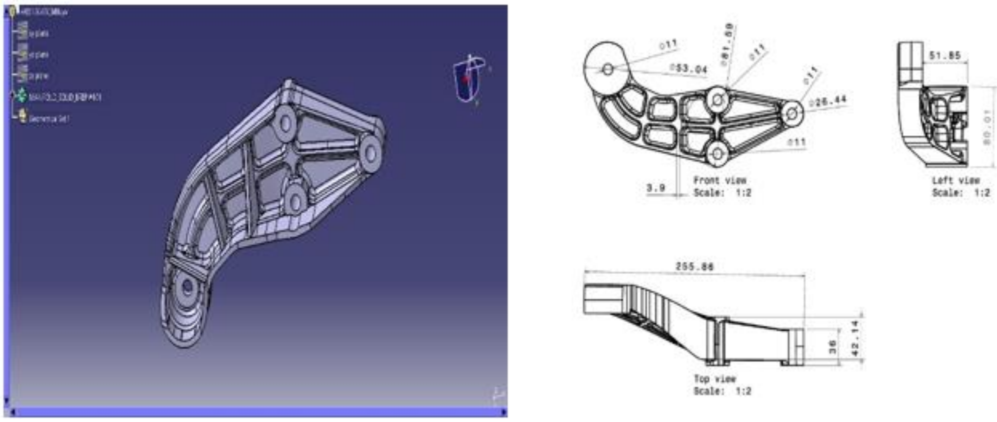

Figure 6.1 illustrates the current Engine Mounting Bracket's 3D model and draft image. The area which is shown in the red circle, there is a rib which has no any assembly in actual application. Therefore, this part has been removed and the modified design of bracket is shown in the fig. 6.2. Both the models are developed in CATIA V5R18. Due to this modification, weight of bracket is reduced from 2.6 kg to 1.7 kg.

VII. THE ENGINE BRACKET - FINITE ELEMENT ANALYSIS

The finite element analysis constitutes a computational tool utilized for the modeling and examination of diverse engineering components. These analytical evaluations are essential for the endorsement or execution of design alterations throughout the post-processing phase. The requisite design adjustments predominantly hinge upon the product life cycle, which aids design engineers in determining the final specifications and constituents of the component. The examination of von Mises stress is executed utilizing ANSYS, whereas the assessment of natural frequencies is carried out employing Abaqus.

Pre- processing :

➢ Material Properties :

Poisson’s ratio (μ)	0.28
Young’s Modulus(E)	$2.1*10^{11}$ N/m^2.
Density	7222 kg/m^3
Yield strength in tension	$2.4*10^8$ N/m^2
Yield strength in compression	$8.2*10^8$ N/m^2

➢ Meshing :

For different types of bodied different type of meshing is used. The type of mesh used is ‘10 Nodes Tetrahedral Structural Solid’.

Solution :

- Loads :

We should know the value of load for the implementation on the mounting bracket. The value of load applied to determine Von- misses stress is 800 N. And during the analysis of natural frequencies, it is checked for free- free condition.

- Solve :

Post- processing :

- Model Acceptance Criteria
- Design Modification Criteria
- Result Interpretation

7.1 CAST IRON MATERIAL PROPERTIES

Cast iron represents a class of iron-carbon alloys distinguished by a carbon concentration that surpasses 2% and a silicon content ranging from about 1% to 3%. While cast iron is typically known for its brittleness, malleable cast iron offers improved ductility. This material is characterized by a relatively low melting temperature and is celebrated for its superior fluidity, castability, machinability, and resistance to deformation. Owing to these beneficial characteristics, cast iron is widely utilized in engineering applications, especially in the production of pipes, machinery, and automotive parts.

7.2 STATIC STRUCTURAL AND MODAL ANALYSIS OF THE CURRENT ENGINE MOUNTING BRACKET

Figure 7.1 illustrates the deformation observed in the current Engine Mounting Bracket. The region experiencing the greatest deformation is located at the connection point to the chassis, with a maximum deformation value recorded at 1.6854 mm.

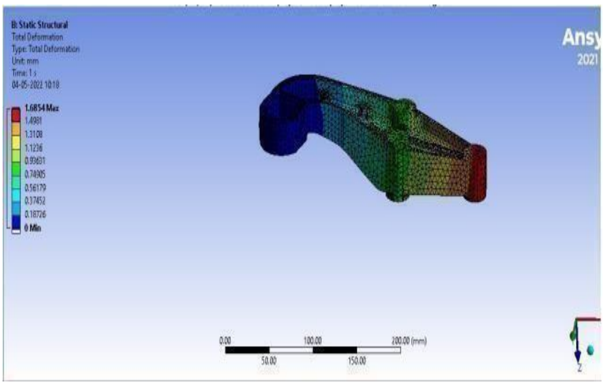

Figure 7.1: Total Deformation of Existing Engine Mounting Bracket

The fig. 7.2 shows the stress distribution along the bottom side of Engine Mounting bracket. The value of stress is 272.15 MPa.

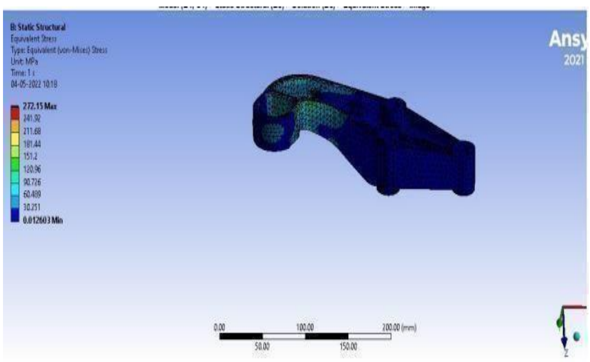

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Figure 7.2: Von- misses stress of Existing Engine Mounting Bracket

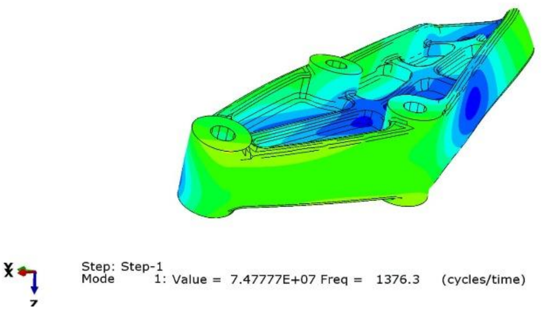

Figure 7.3: Existing Engine Mounting Bracket: 1st Natural Frequency

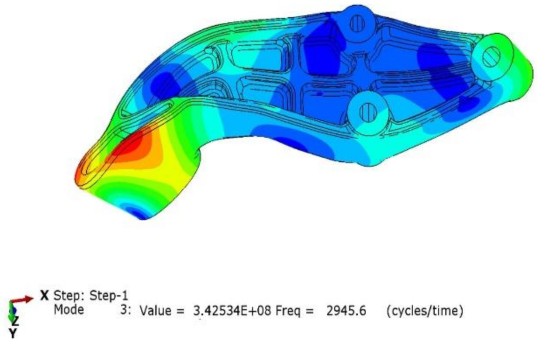

Figure 7.4: Existing Engine Mounting Bracket: 2nd Natural Frequency

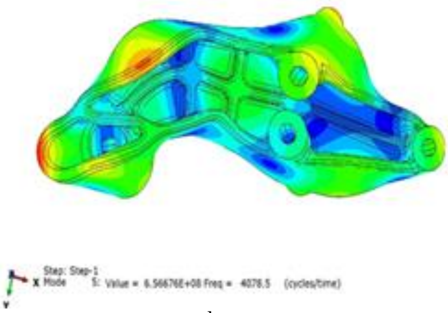

Figure 7.5: Existing Engine Mounting Bracket: 3rd Natural Frequency

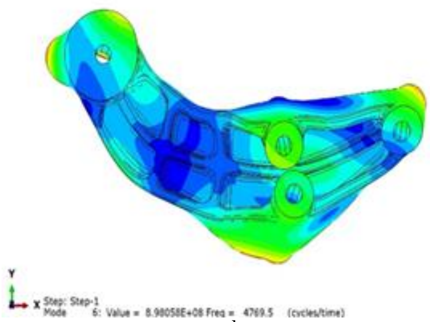

Figure 7.6: Existing Engine Mounting Bracket: 4th Natural Frequency

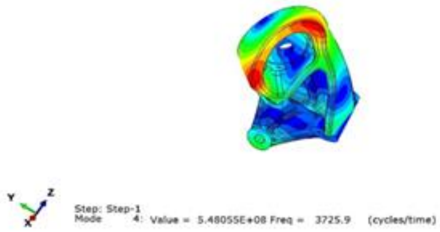

Figure 7.7: Existing Engine Mounting Bracket: 5th Natural Frequency

Figure 7.7: Existing Engine Mounting Bracket: 6th Natural Frequency

7.3 MODIFIED ENGINE MOUNTING BRACKET: STATIC STRUCTURAL ANALYSIS AND MODAL ANALYSIS

From figure 7.5, The analysis determined that the highest degree of deformation occurs at the side of the bracket that is attached to the chassis, with a maximum deformation measurement of 1.3828 mm.

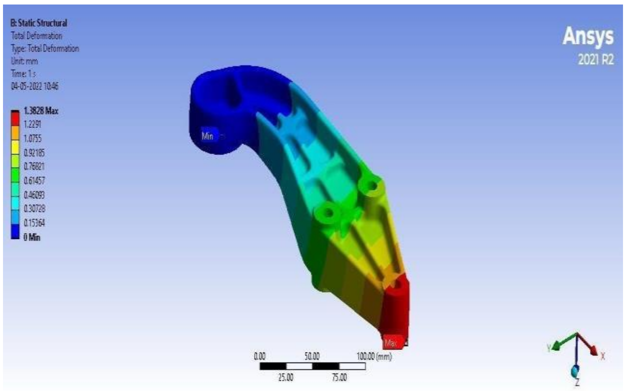

Figure 7.8: Total Deformation of Modified Engine Mounting Bracket

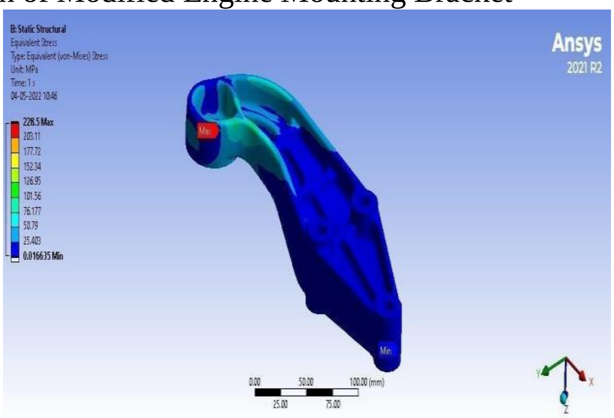

Figure 7.9 illustrates the distribution of stress along the lower surface of the bracket. The value of equivalent Von- misses stress is 228.5 MPa.

Figure 7.9: Equivalent Von- misses stress of Modified Engine Mounting Bracket.

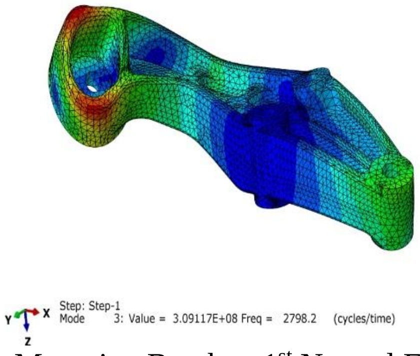

Figure 7.10: Modified Engine Mounting Bracket: 1st Natural Frequency

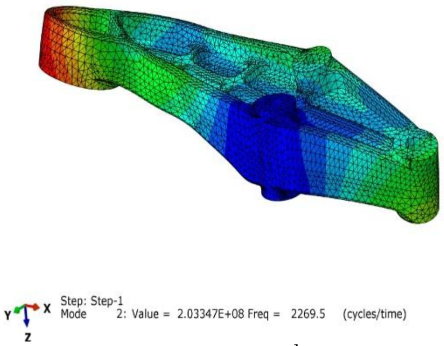

Figure 7.11: Modified Engine Mounting Bracket: 2nd Natural Frequency

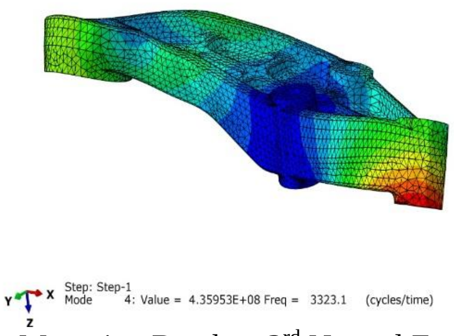

Figure 7.12: Modified Engine Mounting Bracket: 3rd Natural Frequency

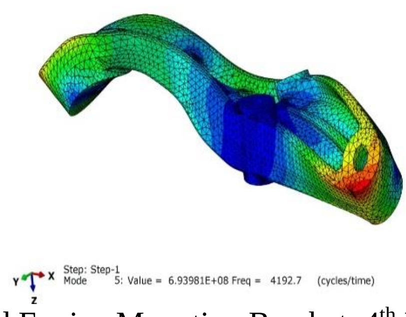

Figure 7.13: Modified Engine Mounting Bracket: 4th Natural Frequency

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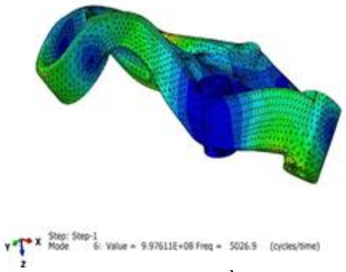

Figure 7.14: Modified Engine Mounting Bracket: 5th Natural Frequency

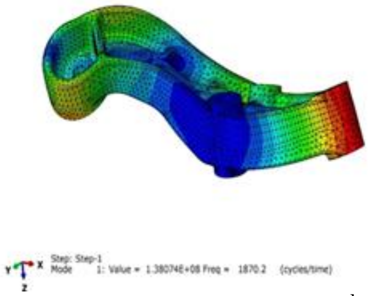

Figure 7.15: Modified Engine Mounting Bracket: 6th Natural Frequency

Table No. 7.1: Comparison Between Natural Frequency of Existing and Modified Engine Mounting Bracket

Sr. No.	Existing Engine Mounting Bracket Natural Frequency in Hz	Modified Engine Mounting Bracket Natural Frequency in Hz
1	1376.3	1870.2
2	1918.4	2269.5
3	2945.6	2798.2
4	3725.9	3323.1
5	4078.5	4192.7
6	4769.5	5026.9

VIII. EXPERIMENTAL ANALYSIS

When performing signal analysis across several application domains, FFT analysis is one of the most used techniques. The Fast Fourier Transform (FFT) is a widely utilized analytical method. It facilitates the conversion of signals from the time domain into the frequency domain. FFT serves as an abbreviation for Fast Fourier Transform. The make of this FFT analyzer is Brüel & Kjær, Denmark. The FFT Analyzer is shown in the figure 8.1.

Figure 8.1 : FFT Analyzer

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8.1 APPLICATION OF FFT ANALYZER

FFT Analyzer consist of Computer, Analogue to Digital Converter, Accelerometer. FFT Analyzer software is installed in computer. Also, One side of Digital to Analogue Converter is connected to Computer and other side is connected to accelerometer. The accelerometer is also connected to Engine Mounting Bracket as shown in figure 8.2. The impact of hammer is perpendicular to the base of bracket. The position of accelerometer is decided by the movement of mode shapes in the Abaqus. The excitation range is selected more than the frequency observed in Abaqus.

Figure 8.2 : Mounting Position of Engine Mounting Bracket

8.2 EXPERIMENTAL ANALYSIS OF EXISTING EMGINE MOUNTING BRACKET

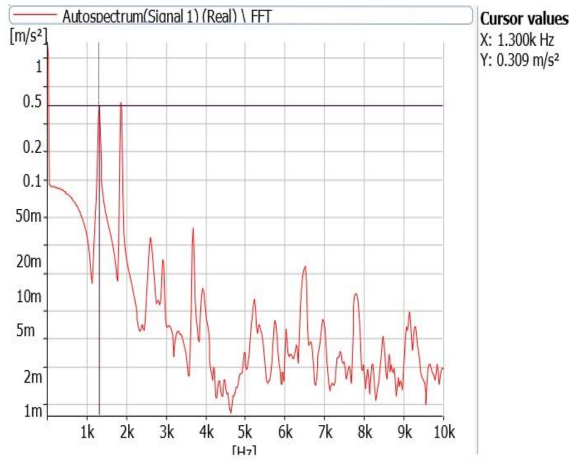

Figure 8.3: Existing Engine Mounting Bracket: 1st Natural Frequency

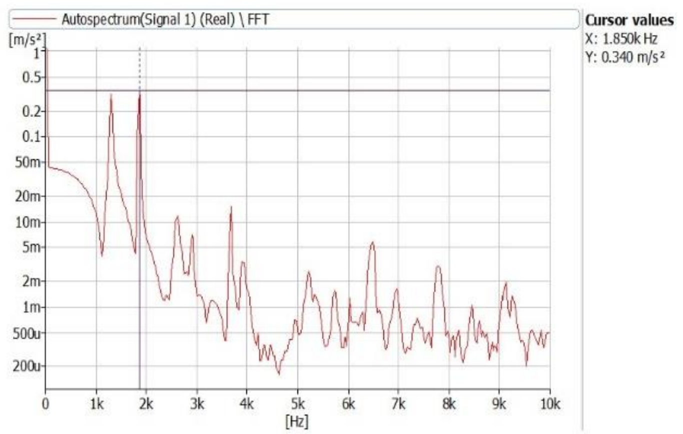

Figure 8.4: Existing Engine Mounting Bracket: 2nd Natural Frequency

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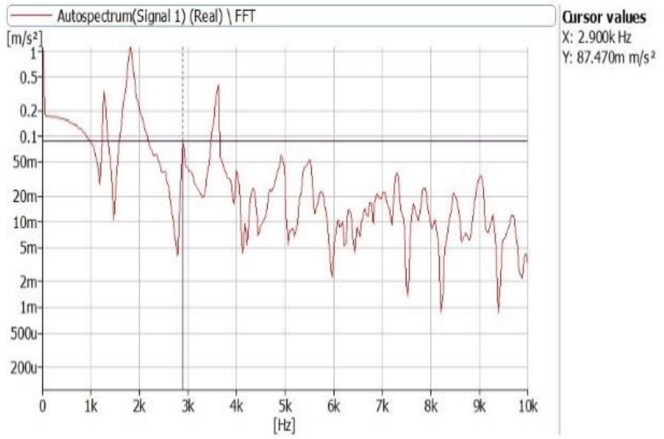

Figure 8.5: Existing Engine Mounting Bracket: 3rd Natural Frequency

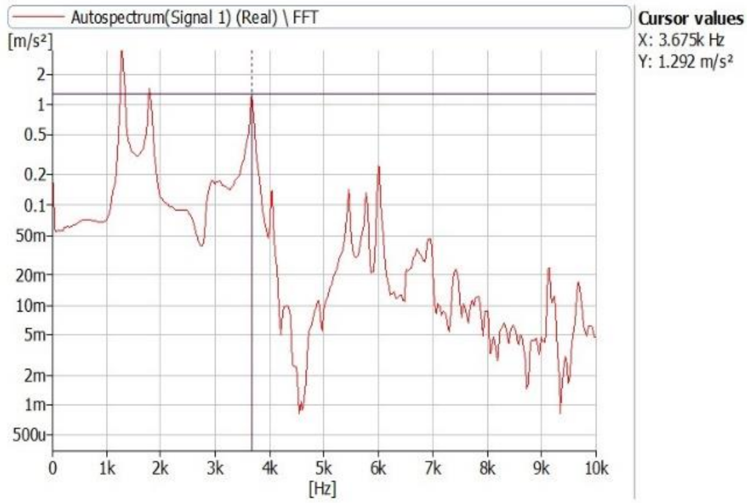

Figure 8.6: Existing Engine Mounting Bracket: 4th Natural Frequency

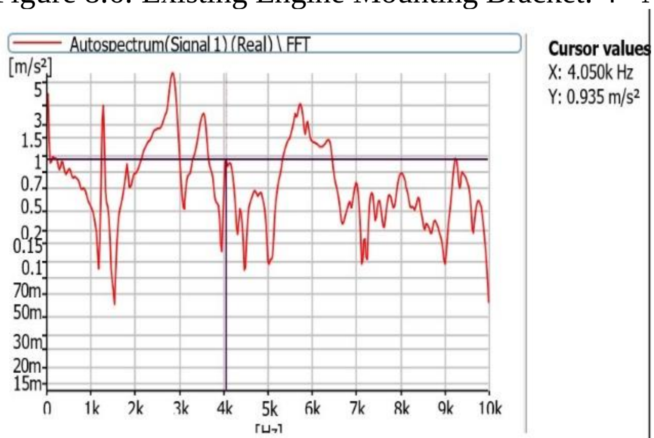

Figure 8.7: Existing Engine Mounting Bracket: 5th Natural Frequency

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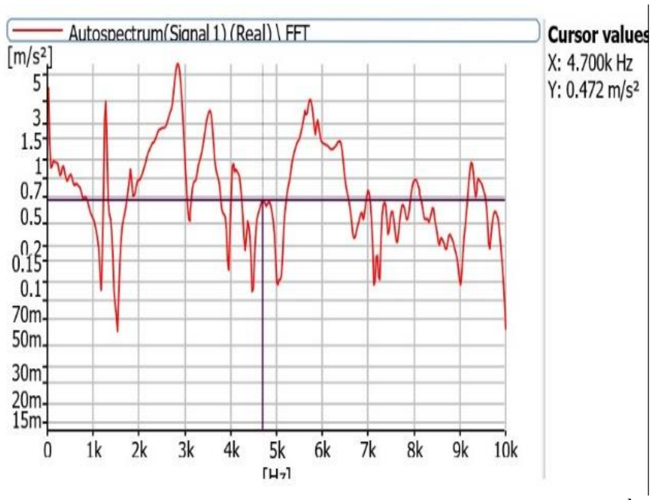

Figure 8.8: Existing Engine Mounting Bracket: 6th Natural Frequency

8.3 EXPERIMENTAL ANALYSIS OF MODIFIED ENGINE MOUNTING BRACKET

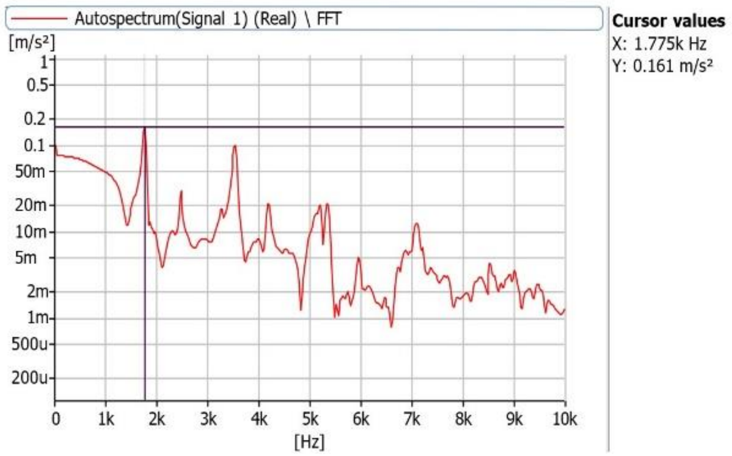

Figure 8.9: Modified Engine Mounting Bracket: 1st Natural Frequency

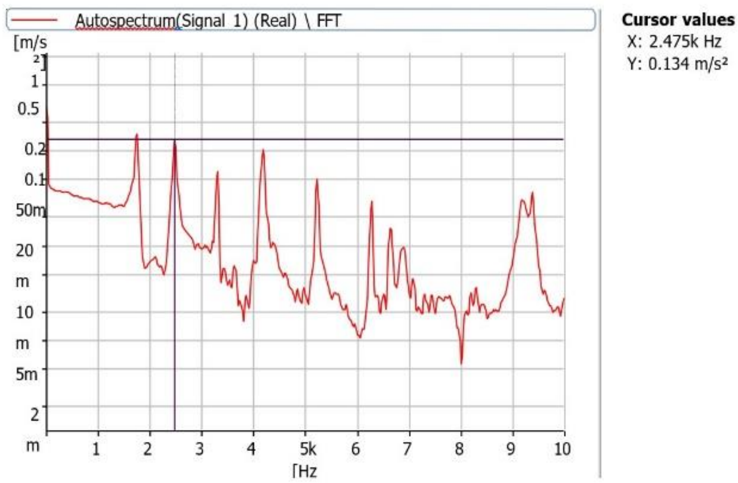

Figure 8.10: Modified Engine Mounting Bracket: 2nd Natural Frequency

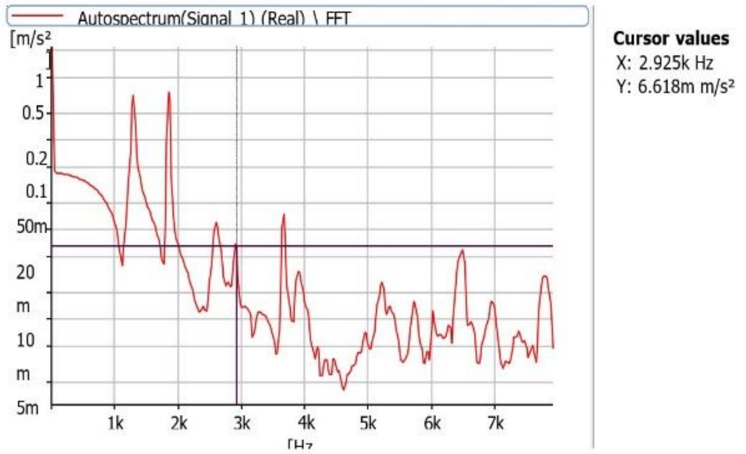

Figure 8.11: Modified Engine Mounting Bracket: 3rd Natural Frequency

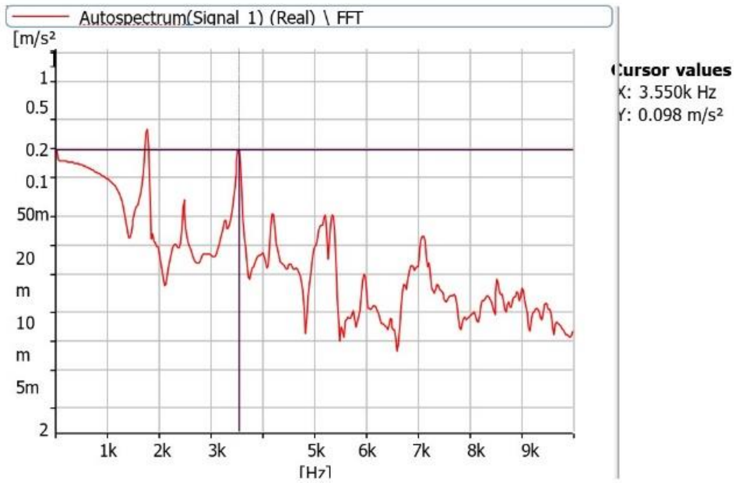

Figure 8.12: Modified Engine Mounting Bracket: 4th Natural Frequency

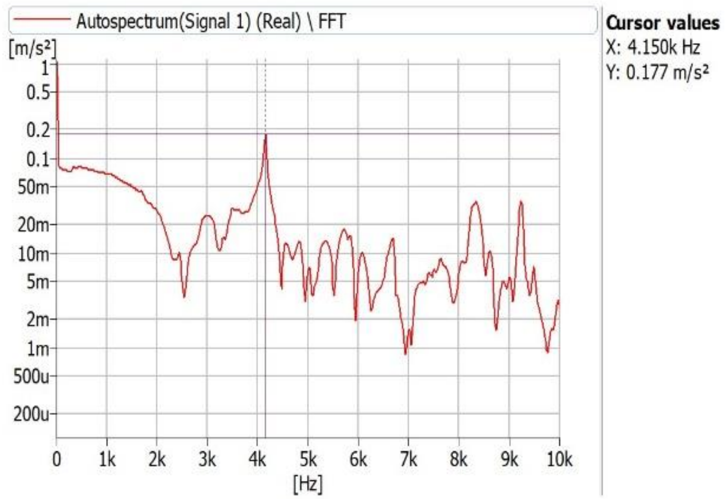

Figure 8.13: Modified Engine Mounting Bracket: 5th Natural Frequency

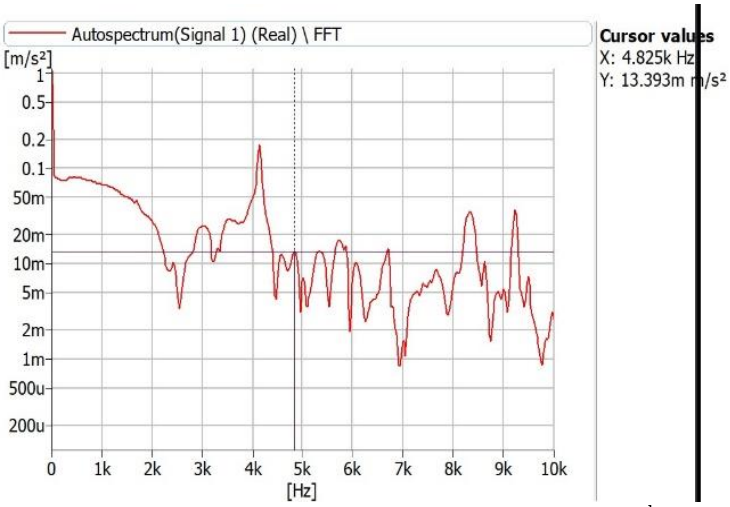

Figure 8.14: Modified Engine Mounting Bracket: 6th Natural Frequency

Table No. 8.1: Comparison Between Natural Frequency of Existing and Modified Engine Mounting Bracket

Sr. No.	Existing Engine Mounting Bracket Natural Frequency in Hz	Modified Engine Mounting Bracket Natural Frequency in Hz
1	1300	1775
2	1850	2475
3	2900	2925
4	3675	3550
5	4050	4150
6	4700	4825

IX. RESULTS AND DISCUSSION

1) After static structural analysis for existing bracket, the total deformation is 1.6854 mm and equivalent Von- Misses stress is coming on bracket is 272.15 MPa.

2) Natural frequency for existing bracket is shown by using Abaqus and FFT analyzer is shown in the table no. 9.1

Table No. 9.1: Existing Engine Mounting Bracket Natural Frequency in Hz using Abaqus and FFT Analyzer

Sr. No.	Existing Engine Mounting Bracket Natural Frequency in Hz	Modified Engine Mounting Bracket Natural Frequency in Hz	% Difference
1	1376.3	1300	5.5
2	1918.4	1850	3.5
3	2945.6	2900	1.5
4	3725.9	3675	1.3
5	4078.5	4050	0.6
6	4769.5	4700	1.4

3) The excitation frequency of engine is 1500 Hz. Hence, from table no. 9.1, it can be said that there are chances of creating resonance. Hence, Engine Mounting Bracket is modified with suitable dimensions as discussed in fig. 6.1 and 6.2.

4) After static structural analysis for modified bracket, the total deformation is 1.3828 mm and equivalent Von- Misses stress is coming on bracket is 228.5 MPa.

5) Table No. 9.2 shows the Natural Frequency of the Modified Engine Mounting Bracket using Abaqus and FFT Analyzer

Table No. 9.2: Existing Engine Mounting Bracket Natural Frequency in Hz using Abaqus and FFT Analyzer

Sr. No.	Natural Frequency of Modified Engine Mounting Bracket (in Hz)	Natural Frequency of Modified Engine Mounting Bracket (in Hz)	%Difference
1	1870.2	1775	1.77
2	2269.5	2475	8.3
3	2798.2	2925	4.3
4	3323.1	3550	6.3
5	4192.7	4150	1.01
6	5026.9	4825	3.9

6) Table 5.2 shows that the natural frequency of the modified Engine Mounting Bracket is greater than that of the existing Engine Mounting Bracket.

7) Also, the weight is reduced from 2.6 kg to 1.7 kg. Cost of existing bracket is 1200rs and it can be reduced to 800rs approximately.

X. RESULTS

1) It can be seen that natural frequency of existing bracket is 1376.3 Hz by using Abaqus and 1300 Hz by using FFT analyzer which is within 10%.

2) A novel engine mounting bracket has been designed, as illustrated in figures 6.1 and 6.2. The weight has been decreased from 2.6 kg to 1.7 kg.

3) The natural frequency for modified bracket is 1870.2 Hz by using Abaqus and 1775 Hz by using FFT analyzer which is within 10%.

4) It is concluded that natural frequency of modified bracket is more than the existing bracket and also more than the engine excitation frequency 1500 Hz. Hence, there are minimum chances of creation of resonance.

5) Static structural analysis revealed that the improved design has a deformation of 1.3828 mm and an equivalent Von-Miss stress of 228.5 MPa, which is within the initial design's total deformation of 1.6854 mm and an equivalent Von-Miss stress of 272.15 MPa.

6) The market value of bracket decreases from 1200rs to 800rs approximately. Because of reduction in weight, it is easy to increase mileage of car.

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