Vibration Analysis of Diesel Engine Muffler by using FEA software

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ABSTRACT

Automotive exhaust system primarily consists of exhaust system as its main component. Mufflers are used to reduce noise and pass exhaust generated in engine. Mufflers are cantilever structures which forms part of exhaust system. They are subjected to various structural, thermal and vibration loads. Various failures are seen in mufflers due to vibration from engine and road excitations. This vibration failure occurs due to resonant frequencies occurring in defined frequency range. Vertical accelerations are dominant in Mufflers due to road excitations. Design/ CAD modeling of existing muffler will be done using CATIA V5 software by reverse engineering. Meshing (Discretization) of model will be done using Ansys Package. Modal Analysis will be done to find out Natural Frequencies and Modes shapes of Muffler. Impact hammer test will be done to find out mode shapes and Natural frequencies using accelerometer and FFT setup. Existing design will be modified to reduce vertical vibrations by use of stiffener ribs.FEA and Experimental methods will be repeated as above. Comparative analysis will be done with FEA and Experimental results for validation purpose. Conclusion and Future scope will be suggested.

Keywords:- *Muffler,FEA Analysis, ANSYS, Cantilever Structure.*

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1. INTRODUCTION

A muffler is a part of the exhaust system on an automobile that plays a major role. It is required to have modes that are located away from the frequencies that the engine operates at, whether the engine be idling or running at the maximum amount of revolutions per second. The meaning of the design project performed was to determine which modes are very high and may affect the automobile adversely while in operation. A muffler that affects an automobile in a negative way is one that causes noise or discomfort while the car engine is running. In order to determine the modes most at risk of adversely affecting an automobile, an impact test was conducted.
Research was performed prior to the test to determine which frequencies to look for modes at. It was determined to conduct the experiment so data from 0 Hz to 1000 Hz could be collected. The force was caused manually by a hammer with a hard head.

2. NEED FOR ANALYSIS

The automobile silencer under steady belongs to a popular 2-Wheeler manufacturer in India with the rated HP of the engine up to @7.69HP. The exhaust gases coming out from engine are at very high speed and temperature. Silencer has to reduce noise, vibration. While doing so it subjected to thermal, vibration and fatigue failures which cause cracks. So it is necessary to analyze the vibration which would further help to pursue future project to minimized crack, improving life and efficiency of silencer.

3. LITERATURE SURVEY

The silencer natural frequencies have been calculated by using the ANSYS package and by FFT analyzer. By both the method the natural frequencies are nearly same and that are useful while the design of silencer to avoid the resonance. Though the dynamic performance can be increased by increasing the thickness of different part, furthermore is to add the support for partition, increase the support etc.[1]

On the basic of vibration analysis of three materials SUS 436J1L have higher deformation then other two material SUS 409L, SUS 436LT and SUS 436LT is the minimum deformation so it is better option for silencer part for manufacturing due to higher life cycle. The value of frequency of materiel SUS 436J1L is the highest at last node of each part of exhaust muffler so it will create more noise so it is not more suitable to reduce the amount of noise emitted by vehicle. [2]

Main drawback of I.C. engines working is that it is a major source of noise pollution. That is why the reduction of exhaust noise generated from engine is in today's world an important issue. Attaching a muffler in the exhaust pipe is the good option for reducing noise. But muffler requires specific design and construction considering various noise parameters produced by the engine. Since early development of mufflers, the main objective of design was attenuation of sound in regular mufflers. This causes a great amount of back pressure at the exhaust port thus losing power, increasing fuel consumption and piston effort to exhale the gases out. For high performance engines the free flow exhaust is made in which the sound level is not important but zero or less back pressure is. There is no intermediate muffler type in between both these, so semi active muffler is an step between these two, in which it attenuates sound when engine is running at low rpm , and converts in free flow when engine at higher revs.[3]

Double expansion chamber gives better results as compared to single expansion chamber. Transmission loss of double expansion chamber is 42.48 which is more than requirement and satisfactory. Also Natural frequency of double expansion chamber is within range of 583.62 to 1001.1 Hz resulting in no resonance. By fixing the muffler at first and double expansion chamber we can increase the frequency and avoid the resonance. Transmission loss of the muffler can be increased by adding protrusion pipe at inlet and outlet. It can be seen that the finite element modal analysis has certain significance in the study of vibration characteristics of the muffler. The time required for optimization of muffler using ANSYS and MATLAB is very short and can be repeated simply after changing the input parameters which provides an easy way to find an optimum solution for muffler design.[4]

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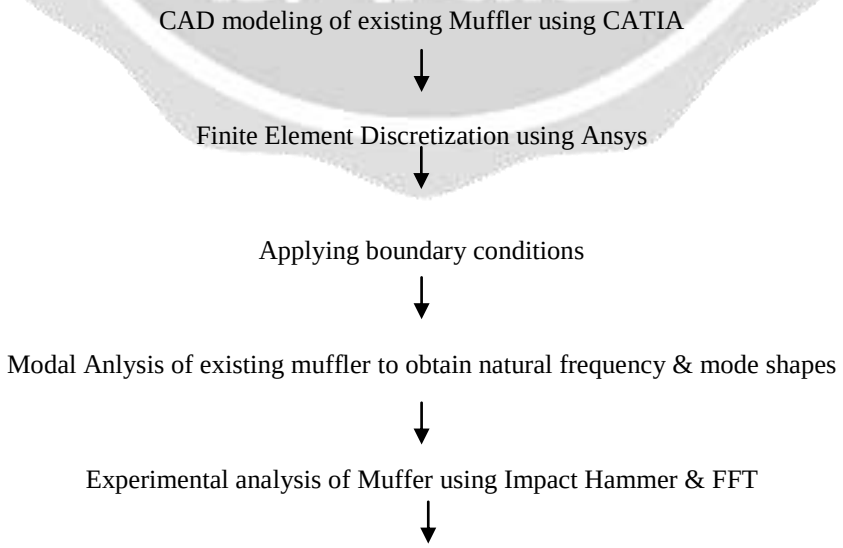
4. METHODOLOGY



Modal Anlysis of Modified muffler to obtain natural frequency & mode shapes

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Experimental analysis of Modified using Impact Hammer & FFT

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Comparative analysis between FEA & Experimental results &Conclusion

5. MODAL & HARMONIC ANALYSIS OF AIR MUFFLER

5.1 Requirement:

- Modal & Harmonic Analysis of Muffler.
- Mode shapes.
- Frequency response plots.

5.2 Technology:

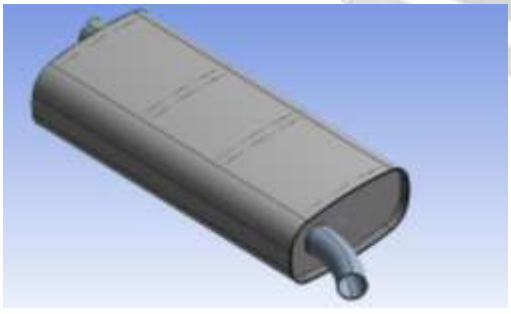
- CATIA V5 R20 for Solid Modeling.
- Ansys 15.0 for Finite element modeling and Analysis

6. MATERIAL PROPERTIE

- Steel
- Modulus of Elasticity : 200GPa
- Poisson's ratio : 0.30
- Density : 7.85e-6 kg/mm^3
- Yield Strength : 520 Mpa

7. FEA ANALYSIS OF EXISTING MUFFLER

a) Solid Model b) Discretization



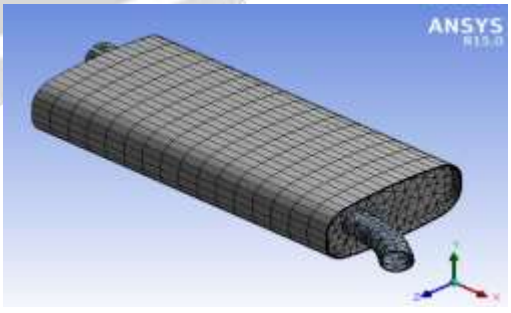


Fig -1 Solid Model of Existing Muffler **Fig-2** Meshing

c) Boundary Conditions

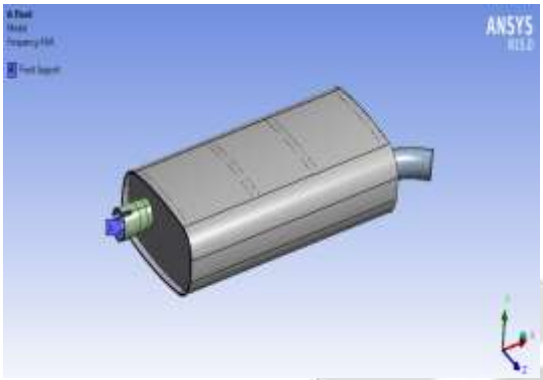


Fig-3 Boundary Conditions applied on Muffler

d) Modal Analysis Existing Muffler

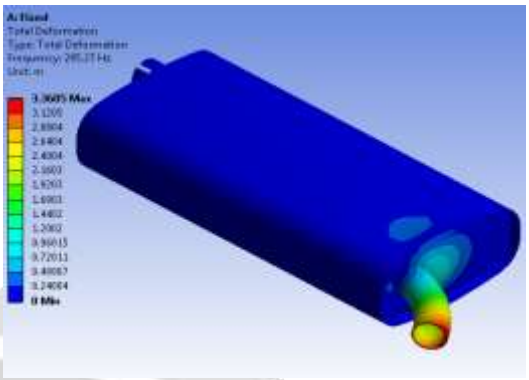


Fig- 4 Natural Frequency for Mode 1

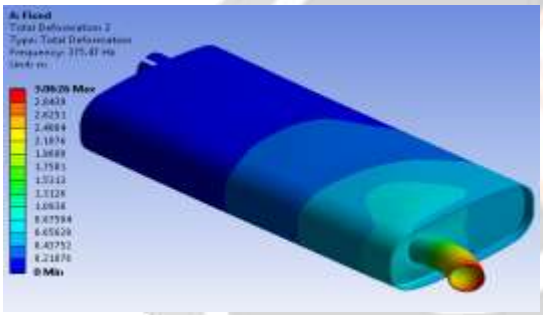


Fig- 5 Natural Frequency for Mode 2

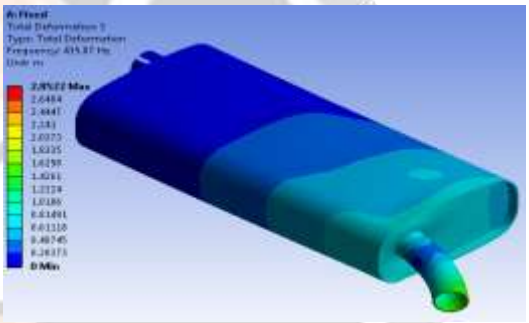


Fig- 6 Natural Frequency for Mode 3

e) Harmonic Analysis

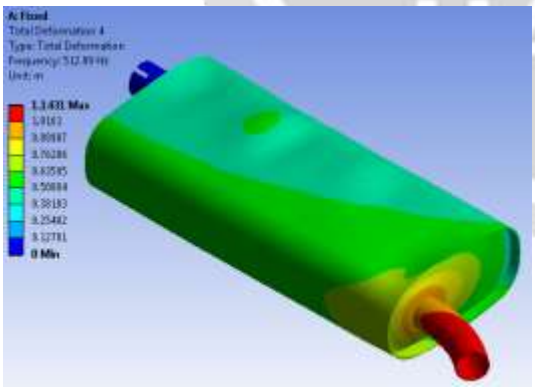


Fig- 7 Natural Frequency for Mode 4

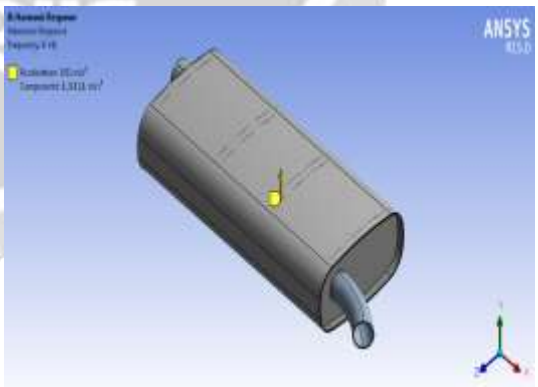


Fig- 8 Harmonic Analysis

8. FEA ANALYSIS OF MODIFIED MUFFLER

a) Solid model

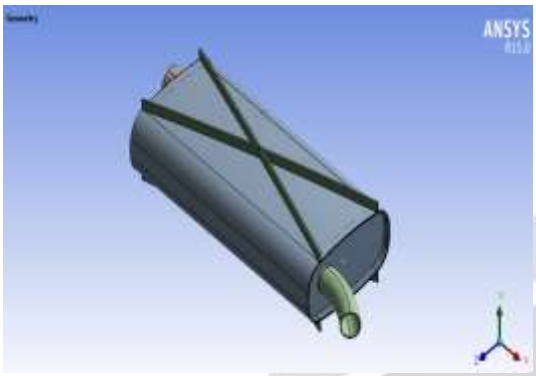


Fig- 9 Solid Model of Existing Muffler

b) Discretization

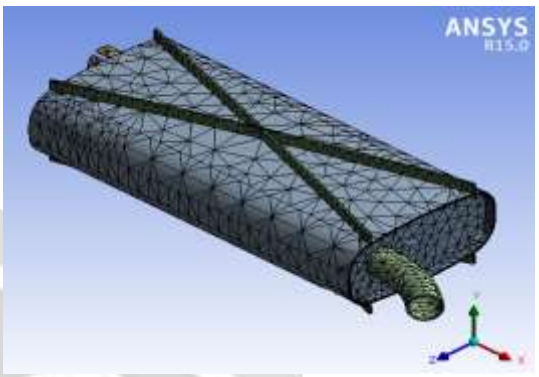


Fig- 10 Meshing

c) Boundary Conditions

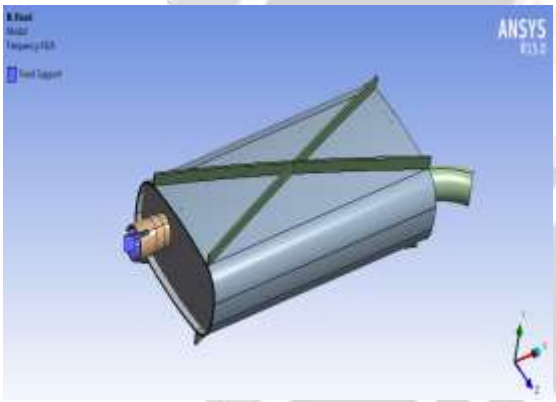


Fig- 11 Boundary Conditions applied on Muffler

d) Modal Analysis of Modified Muffler

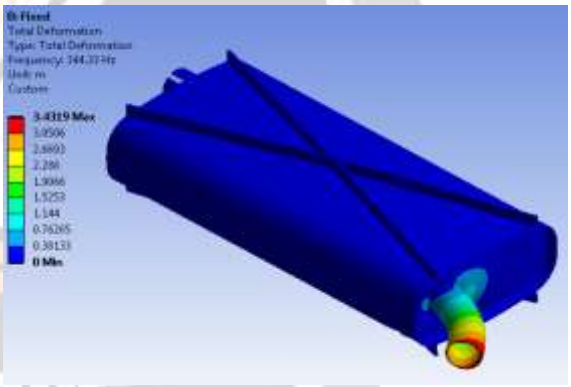


Fig- 12 Natural Frequency for Mode 1

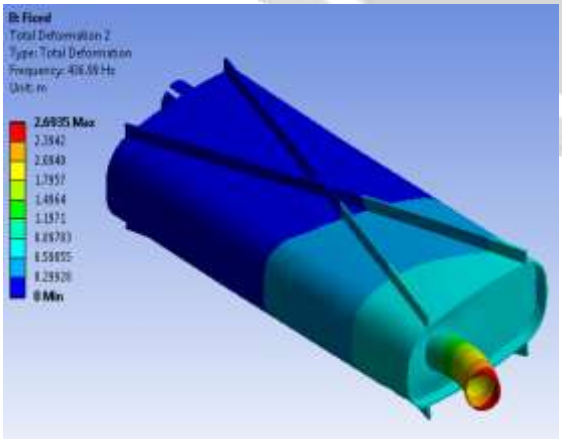


Fig- 13 Natural Frequency for Mode 1

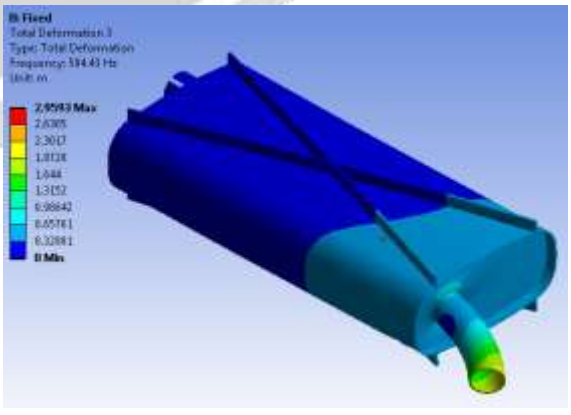


Fig- 14 Natural Frequency for Mode 1

e) Harmonic Analysis

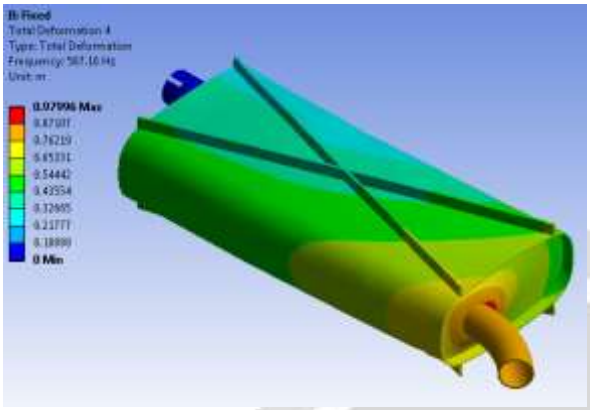


Fig- 15 Natural Frequency for Mode 1

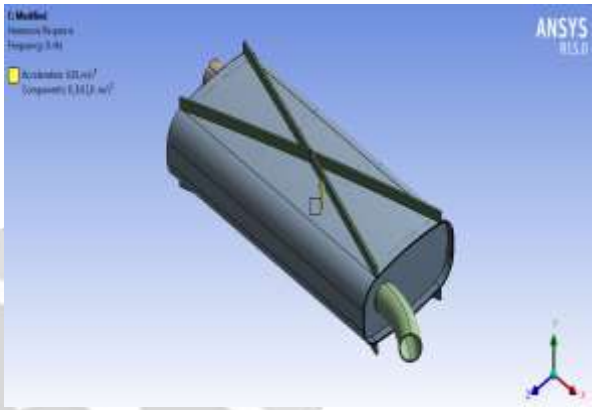
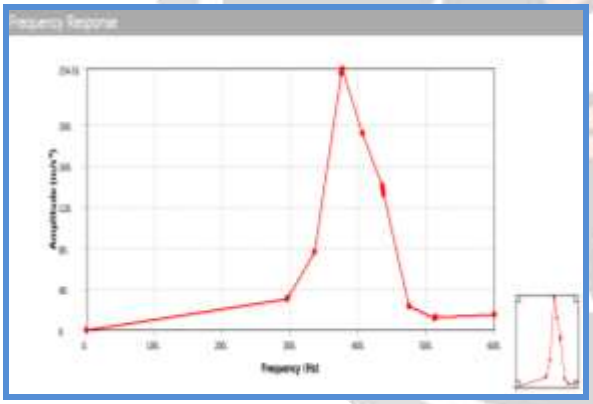
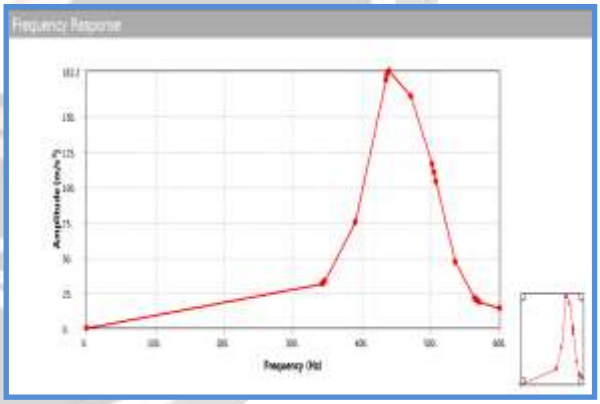


Fig- 16 Harmonic Analysis

9. RESULTS



Graph-1 Frequency Response Curve for Existing Muffler



Graph-2 Frequency Response Curve for Modified Muffler

From The Graph.1, It is observed that as the frequency increases amplitude increases up to 254.51m/s2. This is the result of frequency response curve for existing muffler.Graph.2 is showing the frequency response curve for modified muffler. Modification is done to reduce the vibration. The outcome of the modification is amplitude reduces up to182.2 m/s2.

10. CONCLUSION

In FEA Analysis, for the Existing Muffler, it is observed that for the lower frequency amplitude of vibration is higher while in case of Modified muffler for lower frequency amplitude is lower. So our aim of reduction of vibration has completed by the addition of stiffeners.

11. FUTURE SCOPE

We can verify this Software analysis by experimental Analysis. And also we can perform CFD analysis for Backpressure calculation.

12. ACKNOWLEDGMENT

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BIOGRAPHIES

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