PERFORMANCE EVALUATION OF MUFFLER BY USING FEM AND FFT ANALYZER

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Abstract: Various types of failures and cracks are seen in mufflers due to vibration from engine and road excitations. These vibrations cause localized stresses in muffler. The natural frequency and stresses are analyzed by finite element method. Hence in order to increase the natural frequency and reduce the induced stresses, the structural modification in muffler is proposed and subsequent analysis is carried out. The obtained stresses are below the yield stress limit in X as well as Y direction. Modal analysis is performed to evaluate natural frequency of the muffler. The baffles, perforated pipes, body are the mounting parts tend to vibrate as the excitation frequency of the source (engine).This vibration failure occurs due to resonant frequencies occurring in defined frequency range. The 'frequency match' could lead to a response detrimental to the life of the structure. FEA techniques are used in this work to avoid resonance. Physical experimentation is performed on using FFT analyzer. The aim of this project is to study the existing industrial Muffler. Modeling of existing muffler was created by using CREO Parametric 2.0 software.FEM is carried out for both existing and modified muffler by using ANSYS. Then frequencies, mode shapes and stresses are found. The results obtained from simulation are compared with experiment result by using FFT analyzer and the results are compared with each other.

Keywords: FEA, FFT Analyzer, Natural Frequency, Localized Stresses, Deflection, Acceleration.

I. INTRODUCTION

Engine exhaust noise is controlled through the use of silencers and mufflers. Generally Speaking, there is no technical distinction between a silencer and muffler and the terms are frequently used interchangeably. A silencer has been the traditional name for noise attenuation Devices, while a muffler is smaller, mass-produced device designed to reduce engine exhaust Noise. Muffler or silencer is a device for reducing the amount of noise emitted by the exhaust of an internal combustion engine the muffler absorbs the noise of the exhaust gas and is composed of an outer shell, inner plate's inner pipes, and endplates. It contains a deceptively simple set of tubes that are finely tuned to reflect sound waves produced by an engine so that they cancel each other out. Mufflers are installed within the exhaust system of most internal combustion engines; although the muffler is not designed to serve any primary exhaust functioned. In this project, the existing exhaust system was analyzed through modal analysis by using FEM. Mufflers are 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. In this Project, modeling existing muffler in Creo software and analyzing it for mode shapes and dynamic frequency response analysis in CAE software. It is also tested experimentally and results were correlated it with analysis results and suggest appropriate thickness at baffle plate and reduced the induced stresses, deformation, vertical acceleration in existing muffler.

II. LITERATURE REVIEW

All the reviewed papers showed need of the Muffler in the automotive Sector, its working, performance characteristics, types depends on the applications. Many more papers consist of design iterations for the better performance. Some papers are having FEA iterations for finding out the best model from number of models and adding stiffener for reducing of vibration. Experimental work on FFT is also discussed in some paper. Some analytical methods are also referred. Some papers are having discussed the find out the stresses which are acceptable limit. After studying all above research papers it is observed that mufflers are studied for vibration analysis. In case of practical approach we have observed that an engine has more vibrations. Also, the emission tests for different vibrating conditions are carried out but study on dynamic frequency analysis to find localized stresses induced in muffler and changing the dimension of baffle Plate for better dynamic performance and reducing the vibration without addition of stiffener is less. Therefore in this project FEA methodology is used to find out natural frequency, amplitude, total deformation and stresses induced in muffler is considered for the study.

III. NEED OF STUDY AND OBJECTIVES

The mufflers under study, the exhaust gases coming out from engine are at very high speed and temperature. Muffler has to reduce noise, vibrations. While doing so it is subjected to thermal, vibration and fatigue failures which cause cracks. So it is necessary to analyse the vibrations and to minimize cracks, improving life and efficiency of muffler. The main objectives are:

- To create a model of existing muffler by using Creo Parametric software.
- To carry out the modal analysis, Harmonic and dynamic analysis of the existing muffler for determination of natural frequency, induced stresses, deformation, and acceleration by using ANSYS.
- To optimize the vibration by increase the thickness and hole diameter of baffle plate for better dynamic performance.
- To carry out the modal analysis, Harmonic and dynamic analysis of the modified muffler for determination of natural frequency, induced stresses, deformation, and acceleration by using ANSYS.

- To conduct the experimentation by using FFT analyser for both mode land Compare the results.

IV. TECHNIQUES AND METHODOLOGY

Methodology consists of application of scientific principles, technical information and imagination for development of new or improvised muffler to perform a specific function with maximum economy and efficiency.

Techniques to be used

1. Finite element method.
   a. Model analysis
   b. Harmonic analysis
2. Experimental method (FFT Analyzer).

Methodology

- 2D drawing and 3D model of exiting muffler can be created by using CREO software.
- Natural frequencies, localized stresses of exiting muffler can be calculated by using ANSYS.
- Increase the thickness and hole diameter of baffle plate for better dynamic performance of muffler.
- Natural frequencies and stresses of modified muffler can be calculated by using ANSYS.
- Experimental investigation is to perform on existing as well as modified muffler by using FFT analyzer and results are obtained to find its performance.
- Compared experimental results with FEA results and prediction of muffler can be concluding.

V. FINITEELEMENT ANALYSIS OF MUFFLER

1. Modal Analysis of Existing Muffler

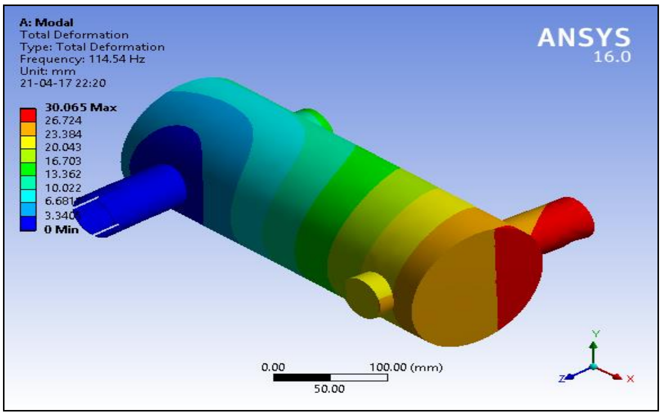

Fig.1 Natural Frequency is 114.54 Hz for Mode Shape1

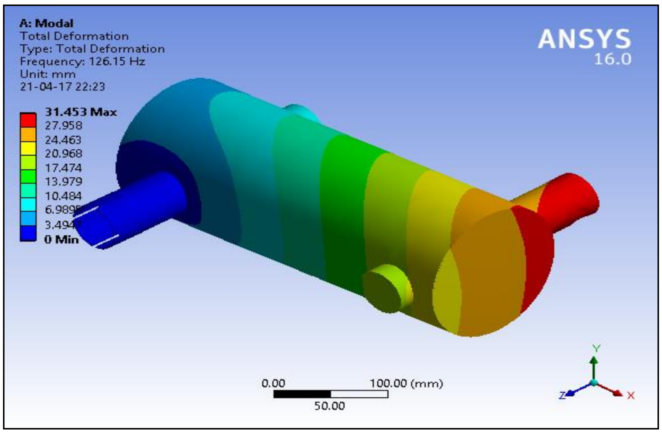

Fig.2 Natural Frequency is 126.15Hz for Mode Shape 2

2. Modal Analysis of Modified Muffler

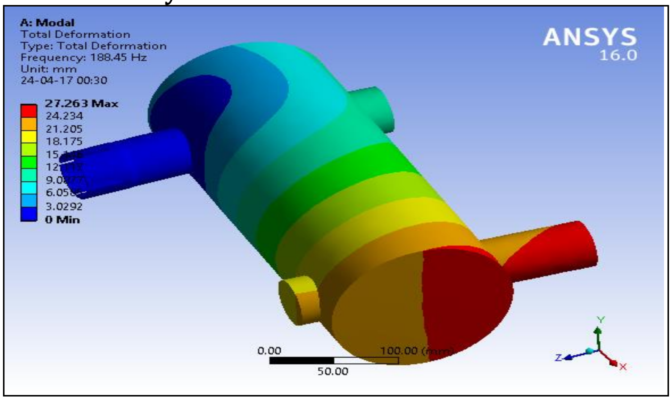

Fig.3 Natural Frequency is 188.45 Hz for Mode Shape 1

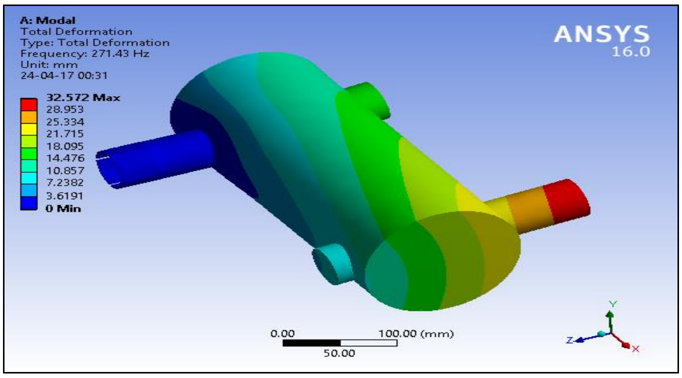

Fig.4 Natural Frequency is 271.43 Hz for Mode Shape 2

3. Harmonic Response Analysis of Existing and modified Muffler

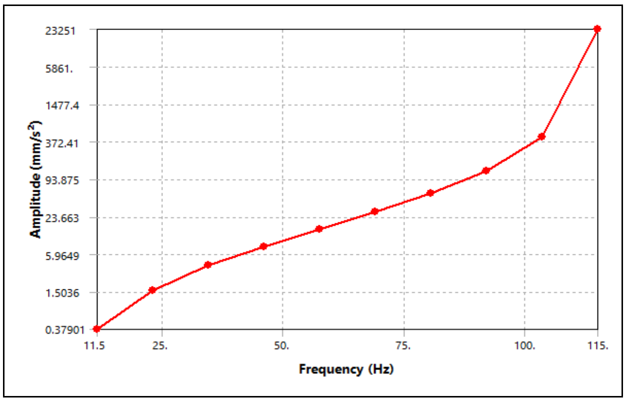

Fig.5 Frequency Response of Existing Muffler

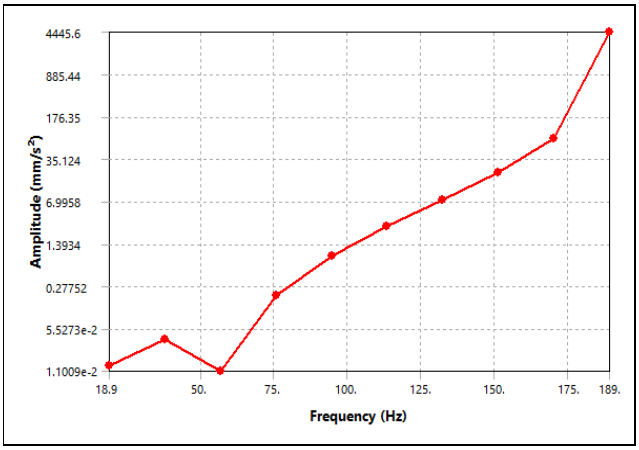

Fig.6 Frequency Response of Modified Muffler

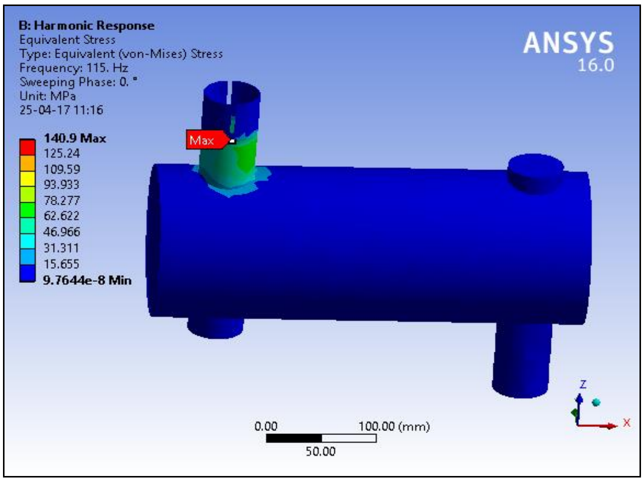

Fig.7 Von-Mises Stress at 115 Hz of Existing Muffler

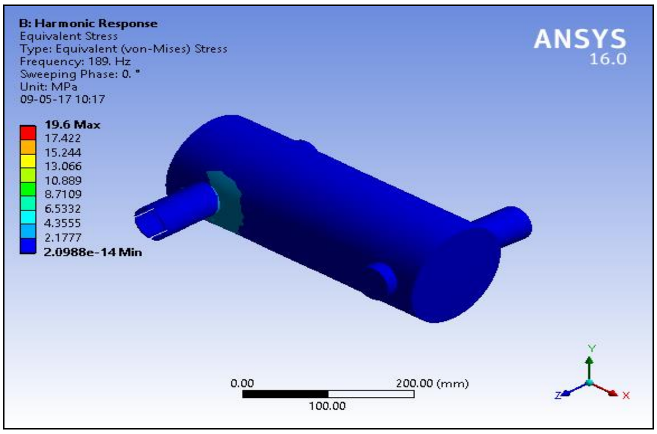

Fig.8 Von-Mises Stress at 189 Hz of Modified Muffler

VI. EXPERIMENTAL ANALYSIS

1. Experimental Procedure

- During analysis first we have carried the experimentation on exiting muffler then modified muffler.
- The setup of FFT analyzer is shown in fig.4.7. The multichannel FFT analyzer is connected to Computer for storing the data in the memory.
- Two probes are connected to measure the acceleration and frequency. One probe is connected to the accelerometer and another is connected to the computer.
- The impact Hammer is used to impact the one end of the muffler to create vibrations. It creates the broad banded excitation signals in the muffler which are considered as ideal for modal analysis.
- For that first hold the exiting muffler in the bench vice. Apply the Hammer at the end which is always connected to the engine to produce excitation signals for modal analysis.
- Then it will create the vibrations in the muffler. The frequency is measured by FFT analyzer. The frequencies are stored in the form of graph for different modes.
- Then we have removed the existing muffler from the bench vice and modified muffler is attached.
- We considered that on addition of thickness and hole diameter of baffle plate the vibrations can be reduced.

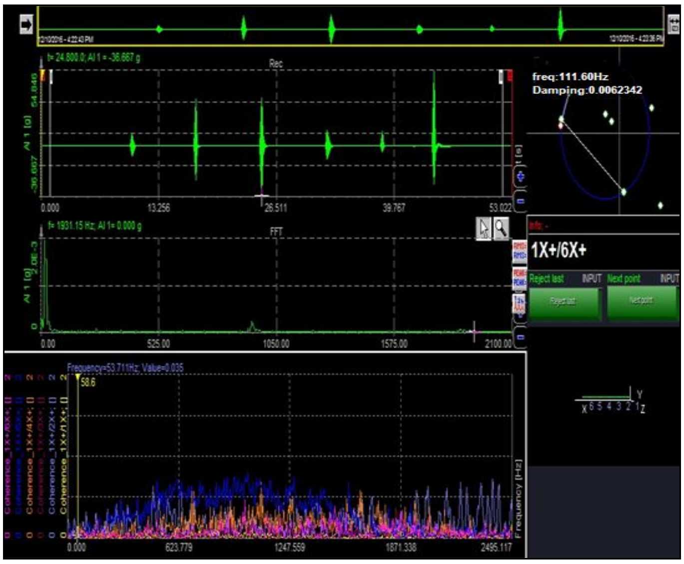

Fig.9 Frequency is 111.60 Hz for Mode 1 (Existing Muffler)

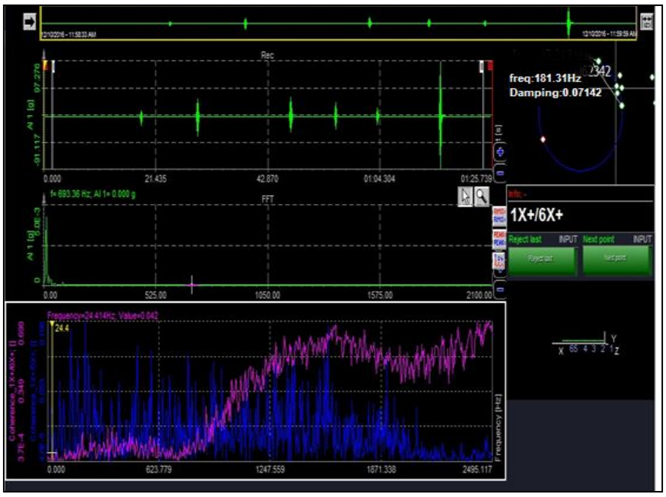

Fig10 Frequency is 181.31 Hz for Mode1 (Modified Muffler)

Fig.11 Frequency is 118.20 Hz for Mode 2 (Existing Muffler)

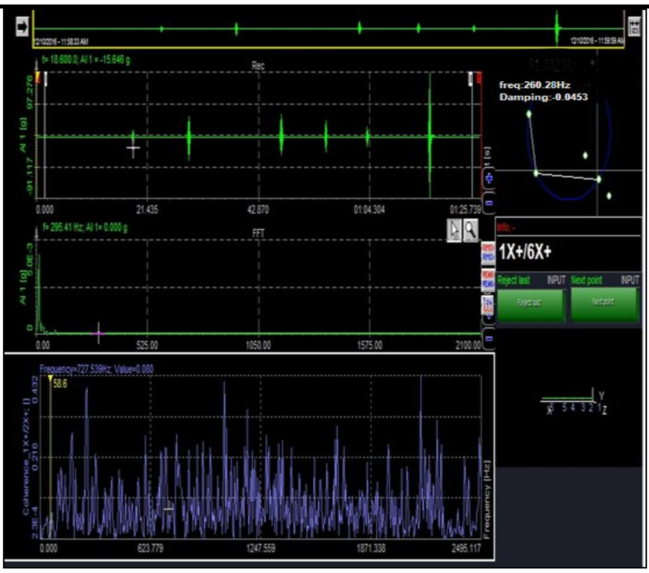

Fig.12 Frequency is 260.28 Hz for Mode 2 (Modified Muffler)

VII. RESULTSAND DISCUSSION

1. Natural Frequencies of Existing Muffler

Mode No.	Natural Frequencies of Existing Muffler (Hz)		
	By FEA	By FFT	% Error
1	114.54	111.60	2.56
2	126.15	118.20	6.30

Natural Frequencies of Modified Muffler

Mode No.	Natural Frequencies of Modified Muffler (Hz)		
	By FEA	By FFT	% Error
1	188.45	181.31	3.78
2	271.43	260.28	4.10

Von-Mises Stress (Mpa)		Acceleration At First Natural Frequency (m/s^2)	
Existing Muffler	Modified Muffler	Existing Muffler at 115 Hz	Modified Muffler at 189 Hz
140.9	19.6	23.251	4.4456

3. Comparison in Stresses and Acceleration

The experimental data was used to validate finite element model representing the real structure. The result indicating that the FE model shows a good correlation with the experimental model for the mode shape. Thickness of the baffle plate changed from 1.00mm to 1.5mm and hole of diameter increased from 28 mm to 35mm. The above changes are incorporated into the model of muffler. With the above changes in geometry of muffler, modal analysis and harmonic analysis is performed on modified muffler geometry and results are shown in above tables.

VIII. CONCLUSION

- From modal analysis, it has been observed that, by Comparing first two natural frequencies of vibration of exhaust muffler by FEA and FFT analyser. The natural frequencies obtained from both the methods are agreeing with each other which are useful for designing of exhaust muffler to avoid the resonance.
- Modified muffler is safe from resonance because natural frequencies of modified muffler are greater than exiting muffler.
- Harmonic analysis was done for both models using FEA. Acceleration is reduced from 23.251 m/s^2 to 4.4456 m/s^2 at first natural frequency by changing the thickness and hole diameter of baffle plate. Thus vibration absorption capacity is increase.
- Frequency response analysis performed for modified muffler geometry showed reduction of stresses compared to existing muffler and these stresses are well below the yield stress limit. Final stresses in modified muffler were reduced from 140.9 Mpa to 19.6 Mpa by changing the thickness of the inlet pipe.

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