ANALYSIS OF EXHAUST MUFFLER BY USING FEM & FFT ANALYZER

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ABSTRACT

A an engine mounted on the vehicle body, a muffler connected to an exhaust port of the engine to reduce the noise level of exhaust gas, a pair of supporting levers to support the muffler, one end of the supporting levers being pivotally connected to the vehicle body and, a pair of linkages pivotally connected between the engine and the muffler supporting levers, whereby a vibration caused by the engine can be absorbed by combined operation of the supporting levers and the linkages. Exhaust muffler is prompted by the need to reduce the engine exhaust noise. Mufflers are cantilever structures which forms part of exhaust system. They are subjected to various loads like structural, thermal and vibration. In most applications the final selection of an exhaust muffler is based on a compromise between the predicted acoustical, aerodynamic, mechanical and structural performance in conjunction with the cost of the resulting system. Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic sound proofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. The Mechanical performance criterion specifies the material properties of the exhaust system to ensure that it is durable and requires little maintenance when incorporated into service. Material selection is especially important in cases involving high temperature or corrosive gases. Various types of failures and cracks are seen in mufflers due to vibration from engine and road excitations. These vibrations cause localized stresses in silencer. The vibrations and stresses are analyzed by finite element method. Modal analysis is performed to evaluate dynamic characteristics of the muffler. The baffles, perforated pipes, body and 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 proposed in this work to avoid resonance. Physical experimentation is proposed using FFT Analyzer. The aim of this project is to study the existing industrial Muffler because study on vibration analysis is less for industrial mufflers So, Vibration analysis is considered for the study of existing industrial mufflers. Design/ CAD modeling of existing and modified muffler will be done using CREO parametric software by reverse engineeringand.FEM is carried out for both mufflers using ANSYS. Then frequencies mode shapes, stresses are found. The results obtained from simulation will be compared with experiment result using FFT analyzer and the results are compared with each other.

Keywords*: -**Industrial Muffler, FEA Analysis, ANSYS,.***

1. 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. The main sources of noise and vibration in an internal combustion engine are the exhaust muffler. The exhaust noise is the most dominant noise source out of all engine noises. And Vertical

accelerations are also dominant in Mufflers which produced sound may be of higher frequency and it creates vibration. To reduce this unwanted noise and vibration, passive noise control elements such as mufflers are usually used.

1.1 Exhaust System

The exhaust system basically consists of a front exhaust pipe bolted to the exhaust manifold, a silencer and a tail pipe. Important of exhaust system has three major functions to channel out the waste products of combustion out of the engine

1. To reduce the noise generated by engine.
2. To clean up the emissions that is harmful to the environment.
3. To reduce the pollution and to increase the efficiency of the engine.

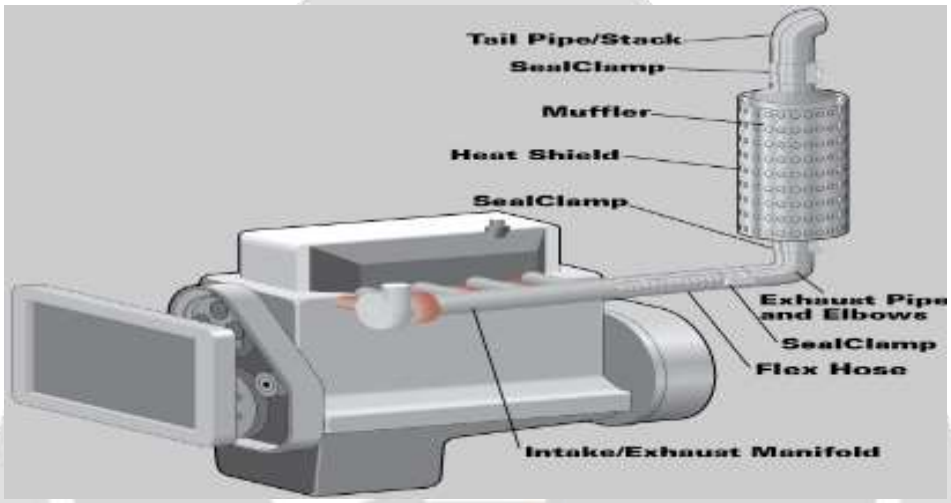

Fig No-1: Agriculture/Industrial Exhaust System

1.2 Components of Exhaust System

1.2.1 Exhaust Manifold

An exhaust manifold is the upper end of the exhaust system. It is attached directly to the side of the engine and is the first part of the exhaust system to receive the burned exhaust gases from the engine. The exhaust manifolds burns any fuel that was inadequately burned by the engine and funnels it down into the main exhaust system. Due to high temperatures, excellent oxidation resistance, high temperature strength, thermal fatigue properties are required.

1.2.2 Muffler / Silencer

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 function. The muffler is engineered as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. 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

2. LITERATURE SURVEY

Many researchers are working on acoustics and vibration analysis of the muffler and persisting to improve the tuning and reduced the vibration of the muffler. It is observed that high noise level and unpleasant noise causes fatigue to human ear and reduces the efficiency of the workers. Various studies have been carried out with different dimensional combinations and altering the internal design of the mufflers.

Vinay Gupta, Dhananjay Kr. Singh worked on Vibrational analysis of exhaust muffler. 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. [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 by Potente, Daniel, Vibrational analysis of exhaust muffler.[2]

Vibration is secondary source of noise generation, by considering the specified material properties and FEM package. The experimental analysis is carried out with the help of FFT analyzer to evaluate the natural frequency and to distinguish it from the working frequency to avoid resonating condition. The dimensions of the existing model of the silencer are referred as benchmarking dimensions to create modified model. Frequency response analysis is carried out to study behavior of silencer at different frequencies and free analysis is done with the help of NASTRAN. [3]

In this paper postulates the first stage in the design analysis of an exhaust system. With the specified properties of the material, the exhaust system is modeled by using a conventional FEM package. The results are compared with the reading taken on FFT analyzer, so as to distinguish working frequency from natural frequency and avoid resonating condition. The muffler natural frequencies will be calculated by using the ANSYS package and by FFT analyzer. By both the method will be compare with each other.

2.1 Comments on Reviewed Papers

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. Experimental work on FFT is also discussed in some paper. Some analytical methods are also referred. Some methods become old and critical for the calculation still that methods are used due to the better result orientation.

2.2 Research Gap

After studying all above research papers it is observed that the diesel engine mufflers and two wheeler mufflers are studied for vibration analysis. Also, the emission tests for different vibrating conditions are carried out but study on vibration analysis is less for industrial mufflers. So, Vibration analysis is considered for the study of industrial mufflers.

3. PROBLEM STATEMENT

The existing exhaust system will be analyzed through modal analysis by using FEM and the validation is to be made experimentally with the help of FFT analyzer. 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. In this Paper, modeling existing muffler in CAD software and analyzing it for mode shapes and frequency response and stress in CAE software. To perform vibration optimization by increasing stiffness or dynamic performance of structure, it is also tested experimentally and results were correlated it with analysis results.

4. NEED OF STUDY AND OBJECTIVES

The industrial 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 analyze the vibrations which would further help to pursue future projects to minimize

cracks, improving life and efficiency of silencer. Specification and design criteria of existing muffler are shown in following table.

Part name	Material size	QTY
Exhaust flange tube	Ø50.8 X1.6THK	01
Exhaust flange	SHEET 15THK	01
Outlet tube	Ø 50.8X1.5 THK	01
Inlet tube	Ø 50.8X1.5 THK	01
Baffle plate	SHEET1.0 THK	01
End plate (front &rear	SHEET1.5 THK	02
Silencer body	SHEET1.5 THK	01

Table-1: Specifications of exiting muffler

Design criteria for existing muffler	
Gas flow	35Kg/ hr. max
Back pressure	40 m bar
Application	industrial/agriculture
Material	Mild steel

Table-2: Design criteria for existing muffler

Fig No-1: Internal Construction of Existing Muffler

Objectives:

1. Modeling of existing muffler, by using CREO software.
2. To carry out the modal analysis, harmonic and dynamic analysis of the exiting muffler and also modified muffler and suggest the appropriate thickness of baffle plate for better dynamic performance and reduced the stresses and vibration.
3. To conduct the experimentation by using FFT analyzer for both exiting and modified muffler and Compare the results.
4. Comparison between all results.
5. Analysis of correlation between results obtained.

5. METHODOLOGY

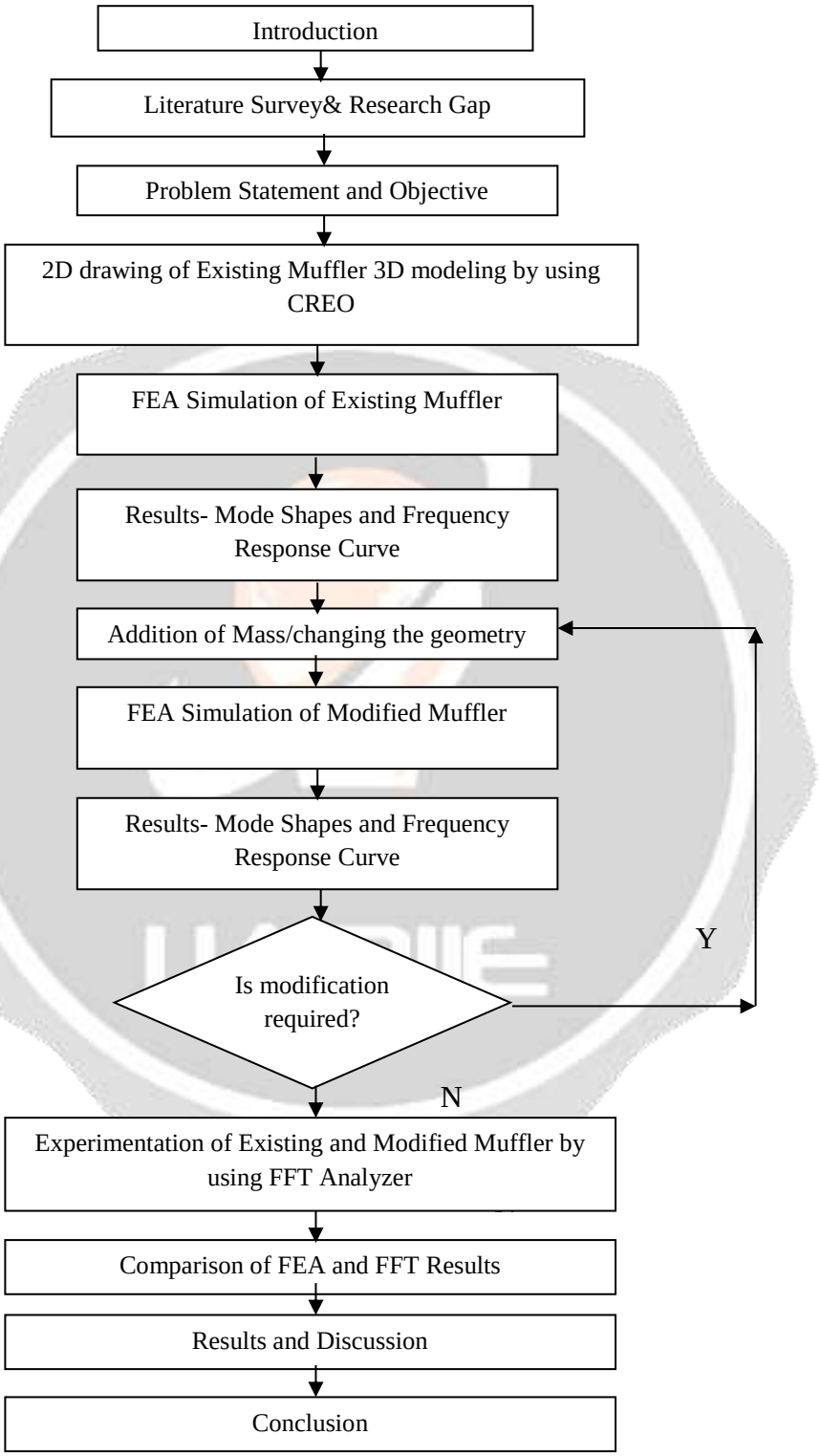

Fig-3: Flowchart of Methodology

6. EXPERIMENTAL ANALYSIS OF MUFFLER

The experimental validation will be done on FFT (Fast Fourier Transform) analyzer because the FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. The advantage of this technique is its speed. Because FFT spectrum analyzers measure all frequency components at the same time, the technique offers the possibility of being hundreds of times faster than traditional analog spectrum analyzers.

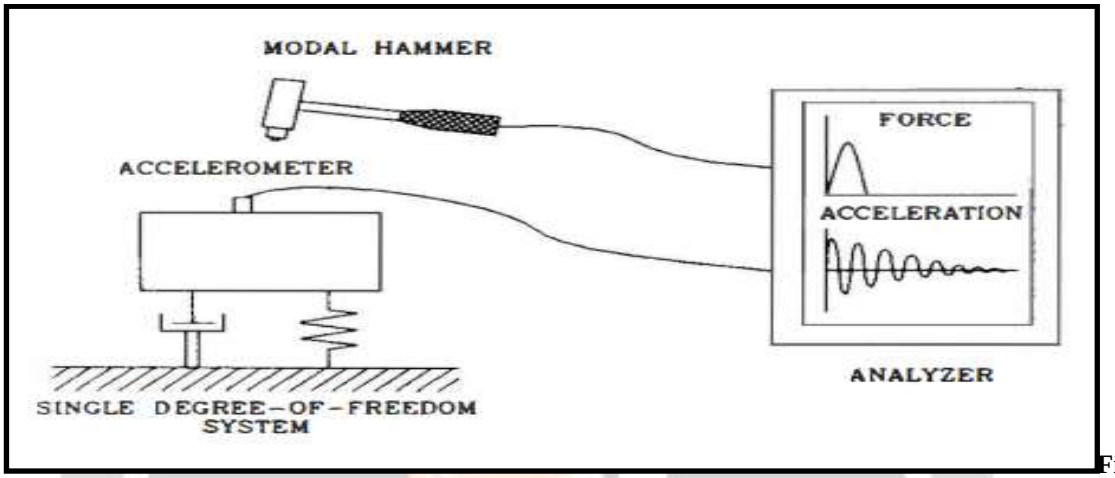

Fig-fig-4: Block diagram of Experimental Set up (FFT Analyzer)

7. EXPECTED OUTCOME

Different types of methods for reducing noise and vibration of muffler are studied. After studying this methods and procedures for reducing a vibration of a muffler, we conclude that in existing muffler is more efficient by changing the geometry or adding proper stiffener for reducing vertical vibration. Existing muffler consist flange tube, exhaust flange, outlet tube, and inlet tube, baffle plate, end plate (front and rear), and silencer body as shown in fig1.2D Drawing of Existing Muffler will be prepared then 3-Dmodeling by CATIA V5 and follow the methodology flowchart to reduced vertical acceleration and localized stresses of the muffler. So we need to add the structural mass or changing the geometry of existing muffler. While adding the mass we have to keep the natural frequency of the muffler constant, and selected the Stiffener of the proper dimensions and weight. Find natural frequencies of vibration of exhaust muffler by FEA and FFT analyzer. The natural frequencies obtained from both the methods will be agreed with each other. Harmonic Analysis will be done for both models using FEA. Vertical vibration of base model will be reduced by adding stiffener or changing the geometry in modified model.

8. REFRENCES

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