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Analysis of Automotive Exhaust Muffler Silencer Using FEA & Experiment

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Abstract

An exhaust muffler is an acoustic sound proofing device designed to reduce engine noise emission. Exhaust noise is generally limited to the fundamental frequency therefore these frequencies should be used as a starting point for preliminary muffler design. Vibration testing is way to determine whether the muffler performs well at all engine speeds. Also vibrations are transmitted from road. In this project we will carry out vibration test by experiment, FEA to get natural frequencies & mode shapes.

I. INTRODUCTION

Automotive silencer is a significant part of the exhaust system. In an automotive engine, pressure waves are generated when the exhaust valve repeatedly opens and emit high-pressure gas into the exhaust system. These pressure pulses generate exhaust sound. As the engine RPM increases, the pressure fluctuations increases and the sound emitted is of higher frequencies. The silencer has to allow the passage for exhaust gases while restricting the transmission of sound. This induces vibrations in the exhaust system. Since, the silencer is at the tail end with limited scope for supporting along its length, the influence of vibrations is most prominent over this component.[4] Also, silencer has to withstand the stresses induced due to fluctuating load. Therefore, it is necessary to

Analyze vibration characteristics of silencer in order to improve the effective life span and performance of the silencer. Finite element method and experimental modal analysis have been commonly used for vibration related problems of the exhaust system. Conducted an impact test on a muffler system to determine the resonant frequencies and suggest

Fig 1: Over View of Exhaust System.

In order to minimize the effects of these resonant frequencies, suggested design improvements were to add damping to the system. [1]

II. COMPONENTS THAT INFLUENCE AIRFLOW OUT OF THE ENGINE

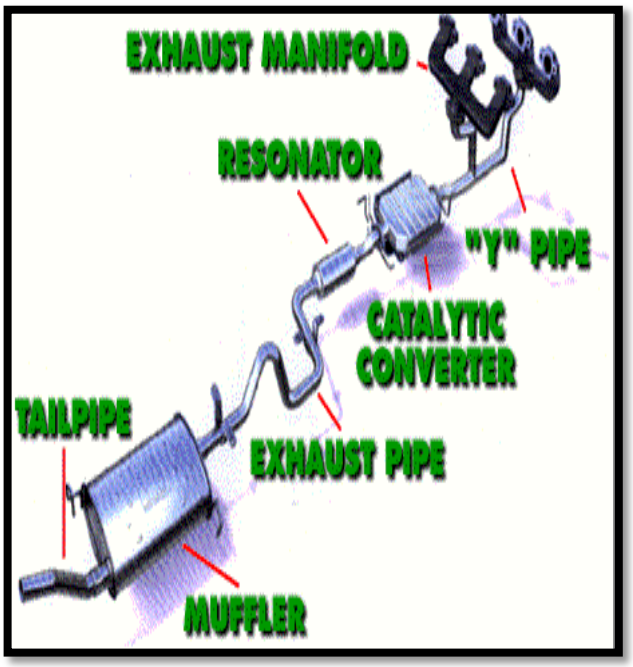
A. Exhaust valve and exhaust ports of the cylinder heads
B. Exhaust manifolds or EKE and Tubing
C. Catalytic converters
D. Muffler
E. Resonator

A. Exhaust manifolds

After completion of fuel combustion process in engine, high pressure gases are realesed.These gases are enters into the Exhaust manifold through pipes.

B. Mufflers

The term muffler is defined as a device for reducing the amount of noise emitted by a machine. To reduce the exhaust noise, the engine exhaust is connected via exhaust pipe to



silencer called muffler.

C. Catalytic Converter

It is a device used for convert harmful gases like carbon monoxide(CO) ,nitrogen oxides(NO) into Harmless gases like CO2 and N2 etc., In present days "three-way" (oxidation-reduction) catalytic converters are widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions.

The various types of mufflers used in automobiles are

1. Baffle type
2. Resonance type
3. Wave cancellation type
4. Combined resonance and absorber type
5. Absorber type mufflers

D. Purpose of Muffler

- An automotive requires a muffler to reduce the amount of noise emitted by a vehicle.
- Mufflers are installed along the exhaust pipe as a part of the exhaust system of an I.C. engine to reduce its exhaust noise.
- Mufflers use neat technology to cancel out the noise.
- The muffler reduces exhaust noise by dampening the pulsations in the exhaust gases and allowing them to expand slowly.
- It was usually made of sheet steel, coated with aluminum to reduce corrosion. Some are made of stainless steel.
- Gases enter through the inlet and must reverse their direction of flow before they exit through the outlet. This is called a reverse-flow muffler.
- Some mufflers use double outer-skins to minimize heat and noise transmission.

III. NEED FOR ANALYSIS

The Automobile silencer under study 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, 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. [3]

IV. LITERATURE REVIEW

A. Vibrational analysis of automotive exhaust silencer based on FEM and FFT Analyzer

When we finding the way of reducing vibration by analyzing automotive exhaust muffler using FEA & experiment the information are obtained by referring the following papers V.P. Patekar presented in July, 2012 and published in International Journal on Emerging Technologies. 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.

B. Performance enhancement of automotive silencer using finite element analysis

Prof. Pravin P Hujare has presented paper along with August 2014 which is published in International Journal of Engineering Science Invention ISSN. This paper based on the design and modification of silencer in order to reduce the vibration which 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.

C. Design, analysis and experimental validation of muffler in an automotive system

This paper presented by Madhu Kumar M, Aravind K U, Dr. Maruthi B H, Dr. Channakeshar valu K in August-2015. This paper based on the present work describes various exhaust noises, vibration and their contribution. Frequency, vibration and noise technique is studied through energy flow. Hence, it is necessary to study the behavior of muffler by analyzing the vibration modes and vibration response. The muffler is modeled using CATIA V5 and FEM is carried out for muffler using Altair pre-processing tool. The free analysis is done using NASTRAN the frequencies and mode shapes are found. The results obtained from CAE simulation is compared with experiment using FFT analyzer. The mode shapes and frequencies are found for both without stiffener and with stiffener and the results are compared with each other. A three-dimensional finite element approach for predicting the transmission loss in Mufflers and silencers with no mean flow

V. OBJECTIVE

The best method to describe the natural characteristic such as frequency, damping, model shapes and its dynamic properties is Model analysis. It involves process of determining the modal parameters of a structure in order to construct a modal model of the response. Both the techniques like theoretical and experimental are different technologies for solving noise and vibration problem. In this experiment Modal analysis will be done for existing model on the basis of modal analysis, we can suggest weight optimization if natural frequencies are higher than the engine frequencies which is basically considered up to 70 Hz followed by Frequency response analysis.[2] If natural frequencies are not within the acceptable limit then we have to shift the natural frequencies out of concerned zone by suggesting some modifications (Change in geometry or mass or boundary conditions) and then frequency response analysis will be done at first resonance frequency to check the stress levels, stress criterion should also satisfy.

VI. SCOPE

The present work having following future scope:

- Vibration of muffler can be reduced by increasing the natural frequencies of muffler by change in geometry or mass or boundary conditions.
- Reduced vibration of automobile and offering good comfort
- Maintain a desired noise and comfortable ride.

- The vibration frequency of modified muffler silencer will be less than existing silencer.

VII. METHODOLOGY

1. Experimental analysis

Here we are carried out following steps:

- Muffler selection
- Test rig for muffler
- Mounting of FFT analyzer
- Input signal of excitation by Impact hammer
- Output signal by accelerometer
- Readings & visualization of vibration
- Data collection

A. Muffler selection: For analysis of automotive exhaust muffler we are select the silencer of Pulsar motor bike.

B. Mounting of FFT analyzer: FFT analyzer is used for measuring resonance frequency. FFT analyzer gets input with respect to time and provides output in frequency spectrum in from of graph or equations.

C. Input signal of excitation by Impact hammer: Input Signal which required for FFT analyzer is given by impact hammer.

D. Output signal by accelerometer: The resonance due to impact hammer forming vibration and this amount of vibration is detect by the accelerometer

E. Readings & visualization of vibration: This amount of vibration is visualized by FFT analyzer.

F. Data collection: These readings of vibration are collected from FFT Analyzer and note it down.

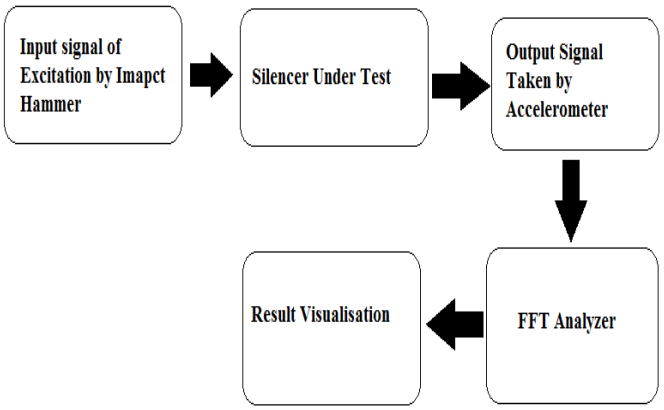


Fig: 2 Block Diagram for Experimental Setup. [4]

Fast Fourier Transform (FFT) analyzer is used to do the experimental validation. FFT analyzer validates the input signal, computes the magnitude of its sine and cosine components and displays the spectrum of the measured frequency components. This method carries advantage of being fast and accurate. The method is faster than traditional analog spectrum analyzers.

2. Finite Element Analysis

The finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. It has developed simultaneously with the increase in use of the high speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis.

Steps in FEM As Follows

- 3D Part Modeling
- Assembly
- Material Selection
- Property Discretization (i.e. Meshing)
- Boundary Conditions (Loads, Constraints)
- No. of modes shapes
- Solver
- Results-Mode shapes, Natural Frequencies, Deformation
- Conclusion
- *3D Part Modeling*: 3D Part modeling is carried out in CATIA V520 software.

- *Assembly:* After 3D part modeling making assembly of those parts in CATIA V520 software.

- *Material Selection:* Select the material for muffler silencer in FEA software like ANSYS 15.0.

- *Property Discretization (i.e. Meshing):* Meshing is carried out of number of modes of given component. And also mention the number of modes, by carried out meshing the software solving the equations and gives the frequency.

VIII. EXPECTED OUTCOMES

1. The silencer natural frequencies are to be calculating by using the FEM & FFT analyzer. The dynamic performance will increase by changing design like by adding stiffener in the form of bead in the modified silencer.

2. The vibration frequency of modified muffler silencer will be less than existing silencer.

3. The stresses induced in the modified silencer are less than permissible yield strength of material.

REFERENCES

[1] Madhu Kumar M, Aravind K U, Dr. Maruthi B H, Dr. Channakeshavalu, Aug 2015, *Design analysis and experimental validation of muffler in an automotive system*, International Journal for Technological Research in Engineering.

[2] K. R. Gadre, june-2015, *Vibration analysis of an automotive silencer*, International journal of innovations in engineering research and technology [IJIERT].

[3] V.P. Patekar and R.B. Patil, July 2012, *Vibrational Analysis of Automotive Exhaust Silencer Based on FEM and FFT Analyzer*, International Journal on Emerging Technologies.

[4] Prof.Pravin P Hujare, August 2014, *Performance Enhancement of Automotive Silencer Using Finite Element Analysis*, International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN.