Vibration Analysis of Two Wheeler Muffler by using FEA Software

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Abstract— Automotive Muffler is a device used to reduce the noise produced by the engine. Muffler is used in automobile vehicles to reduce the noise produced by the exhaust gases of the engine. Muffler is also used in many other engines and generators. The size, shape and construction vary according to the type and size of the engine. The primary function of the muffler is to reduce engine noise emission. A reactive muffler generally consists of a series of resonating and expansion chambers that are designed to reduce the sound pressure level at certain frequencies. The inlet and outlet tubes are generally offset and have perforations that allow sound pulses to scatter out in numerous directions inside a chamber resulting in destructive interference. On the other hand, an absorptive or dissipative muffler uses absorption to reduce sound energy. Sound waves are reduced as their energy is converted into heat in the absorptive material. For both the types of mufflers, uniform distribution of heat is desirable.

Key words: Muffler, Dynamic Performance, Vibrations, Modal Analysis

I. Introduction

Internal combustion engines are typically equipped with an exhaust muffler to suppress the acoustic pulse generated by the combustion process. A high intensity pressure wave generated by combustion in the engine cylinder propagates along the exhaust pipe and radiates from the exhaust pipe termination. The pulse repeats at the firing frequency of the engine which is defined by f= (engine rpm x number of cylinders)/120 for a four stroke engine. The frequency content of exhaust noise is dominated by a pulse at the firing frequency, but it also has a broadband component to its spectrum which extends to higher frequencies. Measurements of the exhaust pipe pressure pulse on a Continental O-200 engine show that the majority of the pulse energy lies in the frequency range of 0-600 Hz. Exhaust mufflers are designed to reduce sound levels at these frequencies.

II. Literature survey

Shailesh Kadre [2010], the main objective of this paper is to develop the methodology to determine the 'g' level coming on the exhaust system for different designs at is assonance condition. The current paper presents the approach to compare available designs of exhaust system, to meet the modal acceptance criteria i.e. natural frequency must be more than 15 Hz and modal stresses within limit, before manufacturing and select best among them. Method includes modal analysis of FEA model of each design using Opti Struct which gives natural frequency and modal stresses. Then it is necessary to find out modal scaling factor which based on the acceleration level. So using Motion View of Altair Hyper Works, dynamic model, consisting of full vehicle with exhaust system, with leaf spring at front and IROS stick type suspension at rear end, for each design is built. Excitation is given at the bottom of tire in the form of sweep sin function to measured acceleration at a particular point, which is useful for modal scaling and then compare results.

Rahul D. Nazirkar, S. R. Meshram, [June 2014], For an automotive exhaust system the noise level, transmission loss & back pressure are the most important parameters for the driver & engine performance. In order to improve the design efficiency of muffler, resonating of the exhaust muffler should be avoided by its natural frequency. Mufflers are most important part of the engine system and it is commonly used in the exhaust system to minimize the sound transmission level which is caused by exhaust gases. The design of muffler becomes more and more important for noise reduction. The solid modeling of exhaust muffler is created by CATIA-V5 and modal analysis is carried out by ANSYS to study the vibration and natural frequency of muffler.

K. R. Gadre, T.A. Jadhav, [June 2015], Automotive silencer plays an important role in dynamic performance of the exhaust system. As silencer is located at the tail end of the exhaust system with minimum support, it is subjected to intense vibrations. 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 silencer. It is observed that natural frequencies are away from excitation frequency. Further, dynamic frequency response analysis is performed with 3G acceleration in all directions varying with frequency. It is noticed that the stresses are concentrated at a joint between inlet pipe and flange and these stresses are above the material yield stress limit in X and Y directions. Hence, in order to reduce the induced stresses, the structural modification in silencer is proposed and subsequent analysis is carried out. The obtained stresses are below the yield stress limit in X as well as Y direction. The FEM results are verified by experimental results.

III. METHODOLOGY

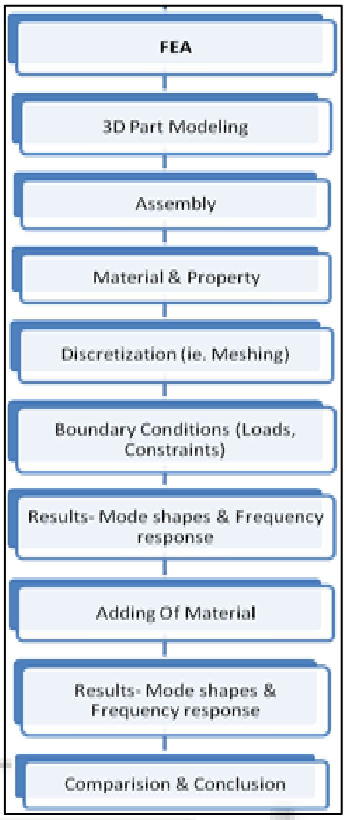

Fig. 1: Flowchart of Methodology

IV. VIBRATION ANALYSIS

Vibration is a common feature of everyday life though most people probably do not reflect much on it. Some vibrations are useful and desirable, as, for example, in music instruments, loudspeakers and machines sorting mixtures of stone and sand. Some vibrations are undesirable or even harmful, as for example in turbine blades, bridges and exhaust systems. Perhaps the most serious vibrations are those arising from earthquakes.

The study of vibrations considers oscillatory motions of a dynamic system. A dynamic system can be defined as "A combination of matter which possesses mass and whose parts are capable of relative motion". This means that all structures, which have mass (inertia) and elasticity (stiffness), are capable of vibrating. The discipline which deals with this is often called structural dynamics.

Vibrations arise as a result of dynamic loading, which sometimes gives a resonant response. This happens when the structure vibrates with such a frequency that stiffness and inertia forces are cancelled out. The frequencies at which this happens are often called resonance frequencies or (undamped) natural frequencies and are associated with certain vibration forms that are called mode shapes. If an undamped system is excited with an external force, which frequency equals a resonance frequency of the system, the response approaches infinity. However, damping, which dissipates vibration energy, is always present in real structures and limits the resonance amplitude.

V. FEA OF MUFFLER

A. *Modeling in Catia V5*

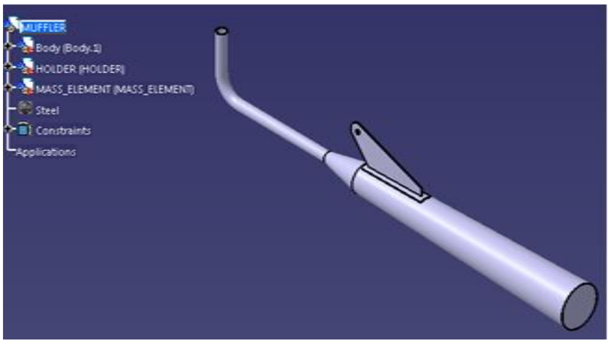

Fig. 2: Modeled in CATIA (V5) software

B. *Modal Analysis of Muffler*

1) *Analysis of Original Muffler*

The three basic FEA process are

- Preprocessing phase
- Processing or solution phase
- Post processing phase

a) FEA Pre Processing For the Muffler

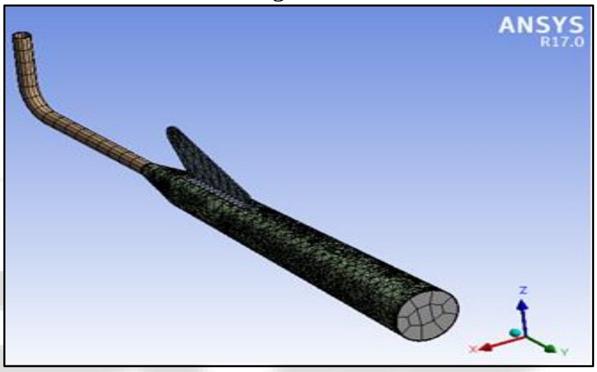

Fig. 3: Meshing of Muffler

b) Post Processing of the Muffler

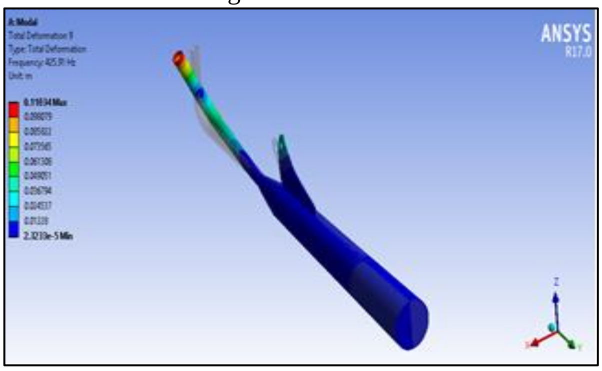

Fig. 4: Natural Frequency for Mode – 01

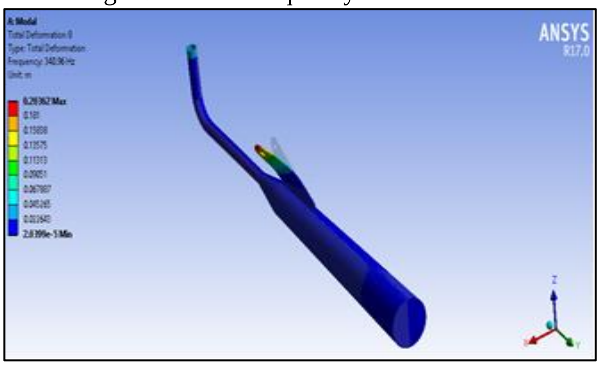

Fig. 5: Natural Frequency for Mode – 02

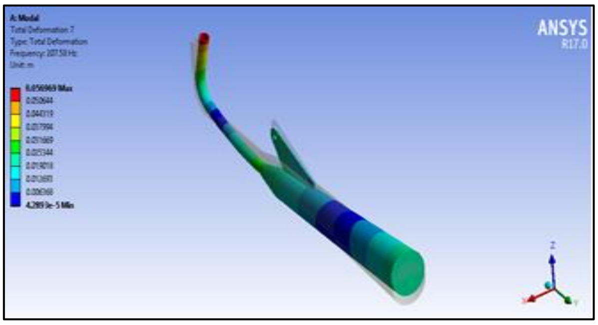

Fig. 6: Natural Frequency for Mode – 03

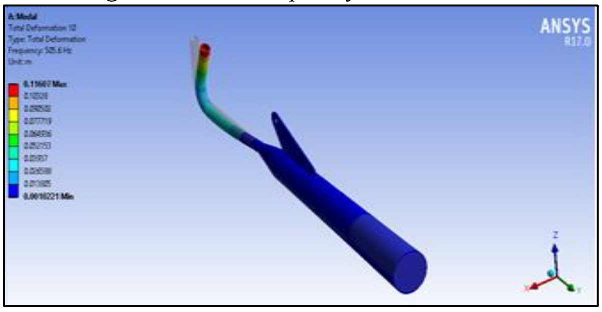

Fig. 7: Natural Frequency for Mode – 04

C. Harmonic Analysis

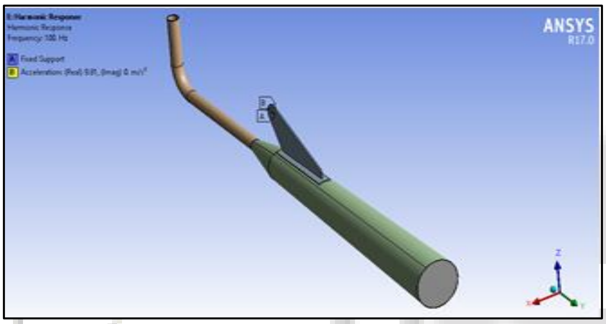

Fig. 8: Boundary Conditions applied to existing muffler

D. Modified Geometry

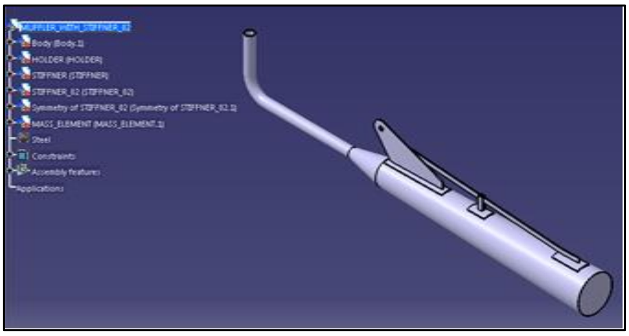
Fig. 9: Modified model

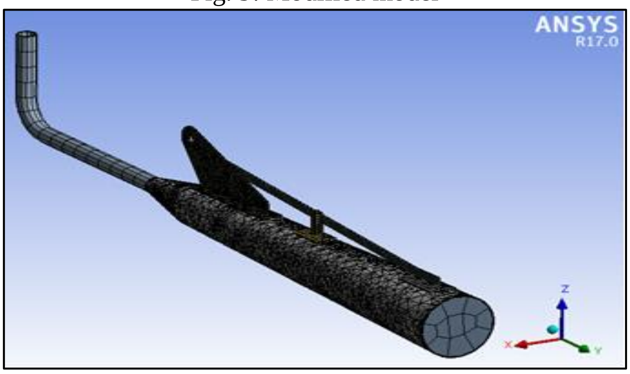

Fig. 10: Meshing Model

E. Post Processing of the Modified Muffler

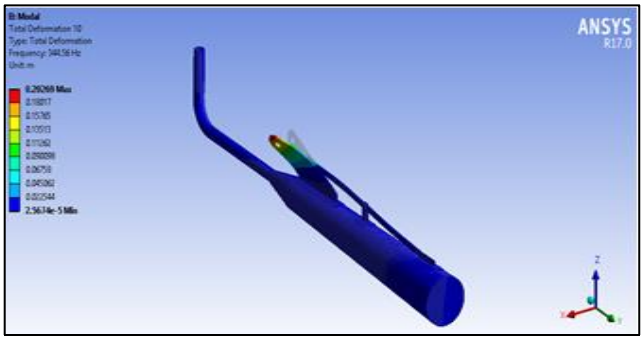

Fig. 11: Natural Frequency for Mode – 01

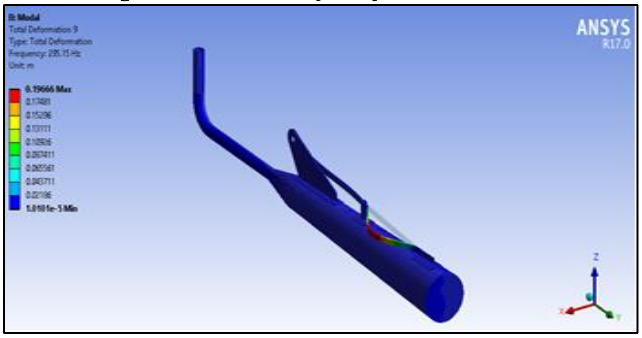

Fig. 12: Natural Frequency for Mode – 02

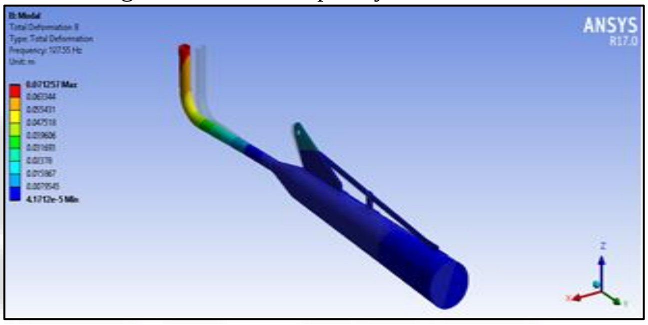

Fig. 13: Natural Frequency for Mode – 03

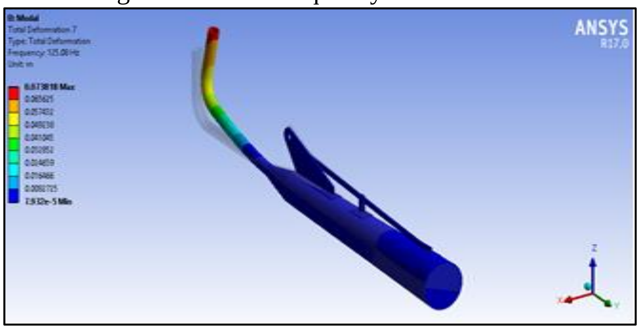

Fig. 14: Natural Frequency for Mode – 04

F. Harmonic Analysis

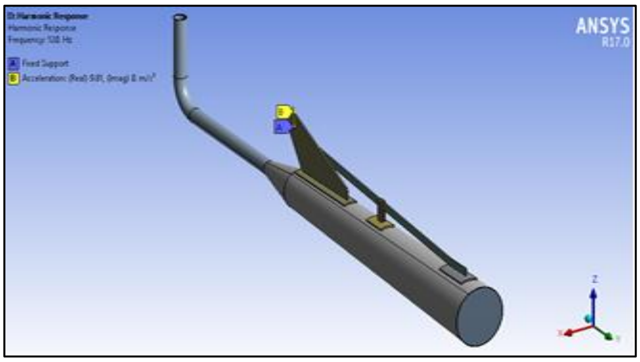

Fig. 15: Boundary Condition

VI. RESULT AND DISCUSSION

Frequency Response at cantilever end is 659 m/sec2at resonance frequency in vertical direction.

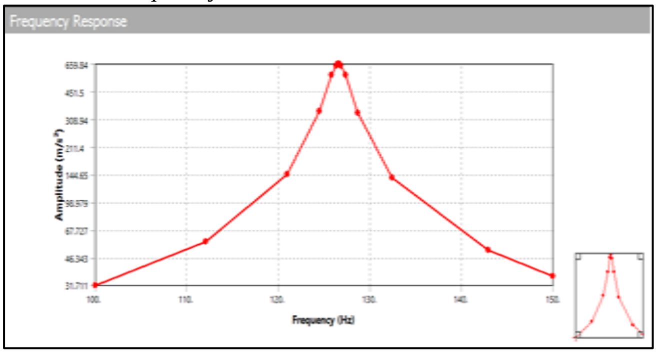

Fig. 16: Frequency Response of existing Muffler

Frequency Response at cantilever end is 3.87m/sec2at resonance frequency in vertical direction.

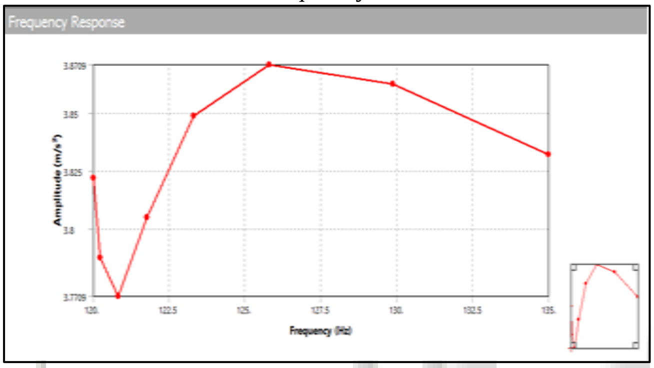

Fig. 17: Frequency Response of modified muffler

VII. 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.

VIII. FUTURE SCOPE

We can verify this Software analysis by experimental Analysis. And also we can perform CFD analysis for Backpressure calculation. We can also go for the thermal analysis. And also can change the material of muffler.

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