Optimization and Passive Noise Control for Six Cylinder Diesel Engine

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Abstract **-** In automobile design of muffler is a challenging task. During the design of muffler it is essential to maintain engine efficiency and damp acoustic sound. IC engine muffler is used to suppress acoustic pulse which is spreading along the exhaust system and reduce back pressure to meet regulation and standard.
Back pressure is major aspect which is affect engine efficiency. In recent competitive world, all to improve focus to improve engine efficiency by reducing weight, backpressure. Traditionally reactive and absorptive muffler is used reactive and absorptive muffler. In reactive muffler suppress a sound but produce back pressure and in absorptive not produce backpressure but suppress sound. Therefore in this paper we are going to develop a muffler for optimum flow which avoid a that problem

Index Terms **-** *Transmission losses, back pressure, muffler design.*

I. INTRODUCTION

The Muffler is a device that is first and foremost used for decreasing the quantity of noise pollution produced by the automotive system or any Machine. To decrease this noise several inhibition steps are carry out. The active way engaged is the usage of Muffler, where it is directly coupled to the exhaust pipe of the engine. Currently mufflers are used for nearly all the automobiles. Some unusual style of mufflers are also used which rise the power output of the engine by decreasing the consumption of the fuel.

Muffler can be passive or active. Their part is to decrease the resonant overpressure of the gas flux, without decreasing the essential pressure for the care of the flux circulation through the pipe lines. The passive silencers decrease the acoustic overpressure based on interference or dissipation and the active silencers are based on calculus systems that accomplishment in actual used for decreasing the noise through interference.

There are two types of passive silencers:
a) reactive;
b) dissipative.

For the design of the reactive silencers reproduced current performs in them, that affects with the direct current and gives to the reduction of the acoustic overpressure level. The dissipative silencers are channels lined with sound absorbing materials or pipe lines with perforated partitions; after these walls there are empty spaces that give to the dissipation of the acoustic energy restricted by the gas flux.

A. Problem Defination

Absorptive mufflers create less backpressure then reactive mufflers; however they do not reduce noise as well.

In reactive muffler reduce a noise but it creates a backpressure. Combination of both not able to solve a problem of back pressure. This noises for the balancing and experiments the engineers to create the exhaust system which will not only decrease the noise level but also will outcome in the fuel efficient engine. The balance requests to be stroked between the engine noise and engine efficiency such that it will offer together fuel effective as low in noise engines.

B. Objective

The purpose of this project to study the current muffler for truck diesel engine, then design the new muffler installing it in the existing vehicle and then comparing and verifying the results with the existing and new values individually.

To design the CAD model using modeling software like U.G and CATIA.

Various designs are create in comparison to the existing muffler of Truck and simulate in software. Extensive work has been passed out on static analysis, dynamic analysis, modal analysis, pressure analysis and software Ansys by approaching FEA method.

II. REFERENCES

Vijay M Mundhe, Eknath R Deore are studied on muffler .Which is an important part of an engine system used in exhaust system to reduce exhaust gas noise level. The literature review reveals that the exhaust gas noise level depends upon various factors. Muffler geometry, extension in inlet and outlet valves, number of hole perforations and its diameter are the factors which affects noise from engines. The objective of this study is to reduce exhaust gas noise level. The performance of the muffler is assessed by analyzing pressure variation, exhaust gas flow pattern, length of expansion chamber, transmission loss. The K-epsilon method is used to obtain desired outputs by inputting sinusoidal nature of pressure wave. The modeling of muffler is done by using modeling software CATIA V5 and performance parameters are estimated using Star CCM+

software. This study helps to improve reduce the noise level and environmental noise pollution. The results obtained from software are compared with analytical method and they are found close agreement with each other.Later on the model with higher transmission loss is selected and the fabrication is done for the same. Exprimental testing is done for the fabricated model. At the end, comparison is done for analytical and experimetal graphs.

M.P.Tambe , Saifali Sanadi , Chaitanya Gongale , Suraj Patil , Surajkumar Nikam works on semi auto muffler. The 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. Which 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.

Dr B.Venkataraman, Gokul Raj are Investigation and Performance Evaluation of Passive Noise Control Components. An internal combustion engine produces excessive exhaust noise. A good exhaust system should control and keep the exhaust noise within the passable limit. Passive noise control techniques are employed to control the exhaust noises. Mufflers acts as a passive noise control elements in an exhaust system which attenuates noise by reflecting the sound wave and cancels it by destructive interferences and by absorbing the sound and dissipate into heat using absorptive materials .The muffler using absorptive materials for attenuating noise can cover a wide range of higher frequencies creating less back pressure while a reflection type muffler works well in lower and mid range frequencies but produces higher back pressure. This papers discusses the experimental results and performance evaluation of both absorption and reflective mufflers which are calculated by sound transmission loss (STL) experiment technique .

P.Chinna Rao, B.Madhava Varma, L.V.V.Gopala Rao are studied on Muffler Design, Development and Validation Methods in which 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. Exhaust mufflers are designed to reduce sound levels at certain frequencies. New regulations and standards for noise emission increasingly compel the automotive firms to make some improvements about decreasing the engine noise. On the other hand, developments on automobile technology and increasing competition between manufacturers necessitates having being reduced weight, having capability of higher sound absorption and lower back pressure mufflers. Lightness could be possible if the thickness is decreased or the volume is reduced. However, this causes high back pressure. Traditionally, muffler design has been an iterative process by trial and error. However, the theories and science that has undergone development in recent years has given a way for an engineer to cut short number of iteration. In today's competitive world market, it is important for a company to shorten product development cycle time. This paper deals with a practical approach to design, develop and validate muffler particularly reactive muffler for exhaust system, which will give advantages over the conventional method with shorten product development cycle time and validation. This paper also emphasis on how modern CAE tools could be leveraged for optimizing the overall system design balancing conflicting requirements like Noise & Back pressure.

III. METHODOLOGY

IV. DESIGN

a. Target setting and Benchmarking –

These phases are also essential to the benchmarking process formulae the base for the continuous improvement cycle. Computing, matching to competition, and detecting opportunities for improvements are the core of benchmarking. The same will be related to silencer, to set a aim in terms of transmission loss and insertion losses of same engine power replicas of benchmarking vehicles.

b. Data collection -

After benchmarking workout, one wants to determine the target uniformities to arrange for more alertness of greater transmission loss. For calculating the goal frequencies engine max power and speed rpm is required. The exhaust noise spectrum will always enclose strong tones correlated with the rate of cylinder firings. In 4-cycle engines each cylinder fires one time every other revolution of the crank shaft. Cylinders fire once every cycle in 2-cycle engines. The lowest tone is always the CFR, which is the firing rate for any one cylinder. The engine firing rate is commonly the strong tone in the exhaust spectrum.

Engines exhaust tones:

Engine 6 cylinder turbocharged intercooled max. Power - 165 hp @ 2400 rpm,Max. Torque - 550 kgm @ 1600 rpm *c. Muffler Design Calculation* -

Based on the knowledge and theory of sound quality for muffler design for various Engines, the following equation ..

Volume of the muffler (Vm):

$$V_m = V_f * [\frac{\pi}{4}(d^2 * 1)] * \frac{N}{2} \quad (4)$$

d. Internal configuration and concept design

On the basis of benchmarking transmission loss and the target frequencies, designer appeals few concepts of internal configuration that meets the packaging dimension within the volume.

Perforations:

The maximum critical component concerning back pressure of any commercial muffler is cross flow perforated tube in which the diameter of the perforated tube hole and sponginess of the perforations are most critical. The perforated pipes are difficult acoustic impedance and are estimated using simple empirical relations.

Perforated pipe forms an essential acoustic portion of muffler, which is measured in line with the difficult frequencies identified in step 2.

$$d_1 = \frac{1.29}{\sqrt{N}} \quad (5)$$

The diameter of the hole to be pressed on the pipe is considered by a thumb rule as given below:

Porosity, σ is given by

$$\sigma = \frac{Area}{C^2} = \frac{\frac{\pi}{4} * d_1^2}{C^2} \quad (6)$$

A smaller whole diameter but greater porosity generates high peak power with suitable back pressure value. While a higher hole diameters with greater porosity reduce performance due to lacking back pressure. Sound energy becomes degenerate significantly while flowing through the perforations and it intensifications to the total decrease in perforated tubes.

Open area ratio:

The open area ratio Aop is given by,

Aop = Area of perforation/Area of the plain sheet …(7)

Less important the Aop greater the transmission loss and improved the acoustic performance. At this stage, the diameter of the hole to be bored, pitch, number of holes per row, number of rows for each shape of holes is stationary and hence, the distance at which perforation starts and at which the perforation ends also gets stationary. Thus, the design of the perforated tube for individual hole patterns is completed.

e. Virtual Simulation –

Based on above stated method, dissimilar concepts will be reached with optimum blends of different elements inside volume of the silencer. Finalized concepts will be shown virtually by computing spread loss and back pressure. Transmission loss (TL) in duct acoustics, collected with insertion loss (IL), defines the acoustic performances of a muffler. It is frequently used in the industry regions such as muffler producers and NVH department of automobile manufacturers. Generally the higher diffusion loss of a system it has, the better it will make in positions of noise cancellation.

V. Testing

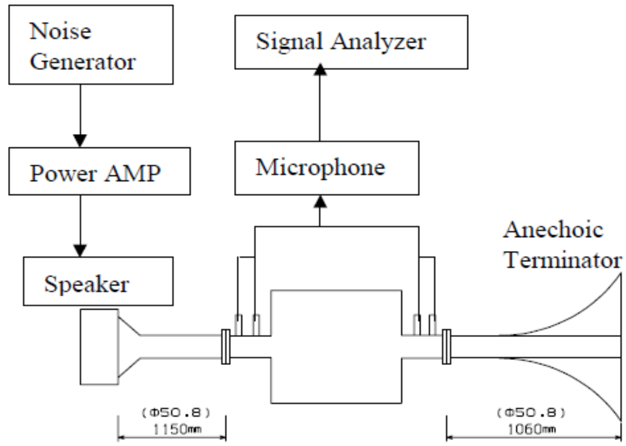

Figure –Testing device and flowchart.

Figure shows the procedure of measuring device for transmission loss and the flow chart of signal.

The calculating target in this test is transmission characteristics of sound wave inside the range of interested

Frequency. We prepared white noise counting the range of interested frequency consuming speakers, and to be found two microphones at each of front and back part of the muffler. The measured data are managed through signal analyzer and calculated the transmission loss.

Experimental Procedure

1. Place the muffler on the essential viewpoint in horizontal location. Verify the horizontal levelling of muffler with level tube.

2. Connect one obstructs tube with the inlet pipe of muffler and tight bushing is practical so that there should not be any leak.

3. Connect obstructs tube to the outlet pipe of speaker through link.

4. Connect the outlet pipe of muffler with the another obstructs tube. Bushing is applied at the inlet and outlet of muffler thus that there must not be any leakage.

5. Involved the four microphone on the impedes pipe to data acquisition method so as to supply the data to acquisition system to quantity the transmission loss.

6. The screen connect with data acquisition system shows the variation of transmission loss.

Back pressure Measurement -

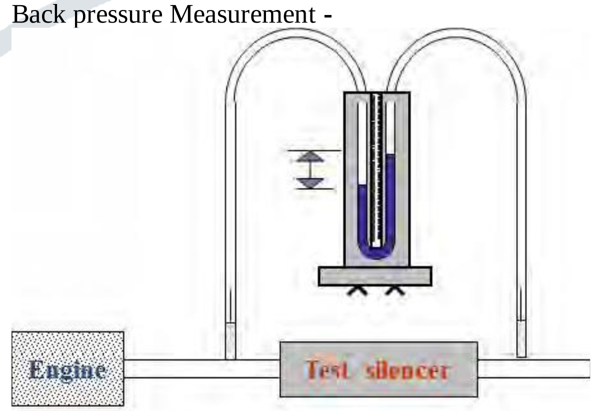

Fig. Diagram of experimental setup for Backpressure Measurement with a U tube manometer

The schematic Diagram of new setup for Backpressure Measurement with a U tube manometer is shown in figure. The pressure taps are situated at a location Upstream of the muffler and another one at downstream of the muffler. The location of the pressure tap should be at such a location where the length and cross unit of the pipe should be continuous sufficient i.e. there are no bends of change in cross section of the pipe.

CFD analyses of the muffler tested in experiment have been performed for two mass flow rates. All the solver conditions, turbulence modeling and boundary conditions have been kept same as in the previous analysis of perforated inner pipe mufflers.

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