International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Design and Analysis of Semiactive Muffler

Dhananjay D.Mahale*, Shailesh L. Deshmukh, Sham H. Borkar, Anand A. Kadav and Ravikant K. Pakale

Department of Mechanical Engineering, MITCOE, Savitribai Phule Pune University ,Pune, India

Accepted 12 March 2017, Available online 16 March 2017, **Special Issue-7 (March 2017)**

Abstract

The Main drawback of IC engines is that it is a major causes Noise pollution. Due to this the reduction of exhaust noise from engines is, an important issue. By the Use of a muffler in the exhaust pipe is the most effective means of reducing noise. Considering various noise parameters produced by the engine some specific type of muffler requires .which have some specific design and construction. So the design of such type of muffler is the Main Aim of design of the muffler and it have the low sound level than the regular muffler. The High Performance engine require to have low back pressure and it is not much affected by sound level Back pressure of the engine is reducing the exhaust gas outlet and it also reduced the efficiency of the engine. So the design of the semi-active muffler can fill these drawback of the conventional muffler used which can reduced the back pressure on the engine.

Keywords: *Noise, Pollution, semi-active muffler, Exhaust port, Fuel consumption*

1. Introduction

A semi active muffler basically operates in two operating conditions:

1) Normal mode (High noise attenuation)
2) Free Flow Mode (minimum back pressure)

In normal operating the major objective is to attenuation of sound well below legal limits of sound pressure level. This muffler acts as a normal muffler giving typical performance of stock muffler made by vehicle manufacturers. The exhaust gases are forced to pass through various restrictions, baffles and sudden change in directions as a factory muffler. This normal operating condition is valid till the engine is running in low RPMs, say till 5000rpm.

2. Placing the figures

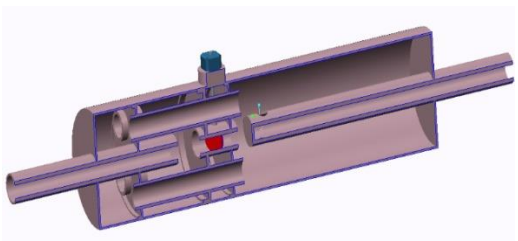

Fig 2.1 Semiactive muffler

Above 5000 rpm the engine is supposed to draw air at capacity close to its maximum and hence there is an urgent need to expel the exhaust gases at a very faster rate than the normal operating conditions. There were the free flow mode switches. In the free flow mode, the exhaust gases in the muffler are almost bypassed but not totally, by using only one expansion chamber for sound reduction instead of all three chambers. In this mode the exhaust gases enters the first chamber and then are exhausted to the atmosphere.

2.1 Problem statement

Increase the efficiency of commercial muffler by changing its design such that gives more brake power in low BSFC during loading condition.

2.2 Objective

-To increase brake power of engine.
-To enhancement of fuel economy.
-To reduce back pressure compared to commercial one.

3. Muffler

Muffler is device which is use in ic engine vehicles for reducing noise pollution. It is also known as silencer because it reduce noise with help of perforated tube. There are two types of muffer generally used in automobile industries. They are:

1) Reactive muffler

*Corresponding author: **Dhananjay D.Mahale**

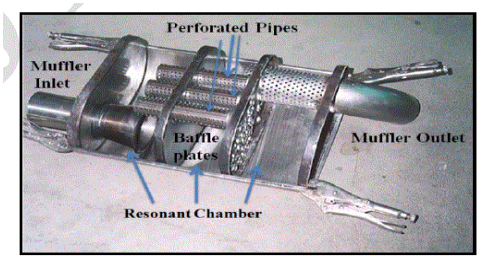

Fig.3.1 Reactive Muffler

2) Absorptive muffler

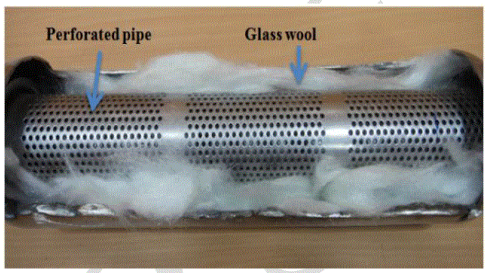

Fig.3.2 Absorptive Muffler

The reactive muffler are the muffler which uses the principle of resonance. They mainly having resonator as their main component which absorbs the high pressure impact of exhaust from exhaust manifold but in case of absorptive type of muffler the absorption principle is used. This absorption of noise due high velocity exhaust gases absorb by glass wool and perforated tube.

3.1 Component of normal exhaust system with their function

1) Exhaust manifold- Takes exhaust gases from engine and guide towards Catalytic converter.

2) Catalytic converter- Convert exhaust gases from manifold into non pollinating elements.

3) Muffler-Act as a silencer.

4) First chamber with perforated tube-Reduce the noise of exhaust by passing it through perforations

5) Second chamber with resonator-Absorp high velocity of exhaust gases.

6) Third chamber with tail pipe-guide the exhaust to environment

4. Difference between normal muffler and semiactive muffler

In case of normal muffler the exhaust from catalytic converter goes into perforated tube and after that it pass to the tail pipe. In case the velocity of exhaust increase then the resonator plays an important role which absorp the high velocity of exhaust. But in this case the back pressure on the system increases which in turn increase the specific fuel consumption and reduce the efficiency of engine. In semiactive muffler the back pressure is reduce due to use of butterfly valve which is act as resonator. Component of semiactive muffler:

1) Exhaust manifold- Takes exhaust gases from engine and guide towards Catalytic converter.

2) Catalytic converter- Convert exhaust gases from manifold into non polluting elements.

3) Muffler-Act as a silencer.

4) First chamber with perforated tube-Reduce the noise of exhaust by passing it through perforations.

5) Second chamber with butterfly valve-Absorp high velocity of exhaust gases by passing directly exhaust to atmosphere.

6) Third chamber with tail pipe-guide the exhaust to environment.

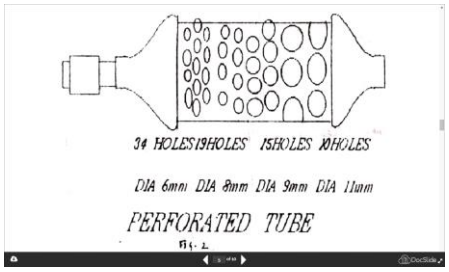

Fig 4.1 Perforated tube

5. Working of semiactive muffler

Fig. 5.1 Prototype

In semiactive muffler the exhaust gases from catalytic converter enter into perforated tube. In perforated tube the pressure is reduced due to escapement of gases from holes of perforated tube. From perforated tube it enters into second chamber and then pass to atmosphere through tail pipe. In case if load on the vehicle increase the engine will produce the high power which will produce the high volume of gases with increase velocity. Due to increase in velocity it will increase the back pressure. In order to handle this back pressure butterfly valve is use which will open and directs the exhaust output to the atmosphere. The butterfly valve is design according to pressure comes on it. It has dead weight on it which is lifted when the pressure exceeds the limit. The use of semiactive muffler will reduce the break specific fuel consumption of engine and increase the overall efficiency of engine.

Advantages of semiactive muffler

1) Reduce back pressure on the engine

2) Reduce the break specific fuel consumption

3)Increase the engine efficiency.

4)Increase in exhaust rate with reduced back pressure

Disadvantages of Semiactive muffler

1)Increase in noise by 1-2%

2)High cost

5.1 Effects of increased back pressure

By continuously increasing back pressure levels, the engine has to compress the exhaust gases at higher pressure which can requires additional mechanical work which can affect intake manifold boost pressure. This leads to an increase of fuel consumption, PM and CO emissions and exhaust temperature. An increase in nitrogen oxide emissions can also be done due to increase in engine load. The rise exhaust temperature can provide an overheating of exhaust valves and the turbine. The Increased of back pressure can gives in performance of the turbocharger, results in changes in the air to-fuel ratio increases which may be a main cause of emissions and engine performance problems. Increased exhaust pressure helps to prevent some exhaust gases from leaving the cylinder (especially in naturally aspirated engines), with the help of an internal exhaust gas re-circulation system which responsible for some nitrogen oxide reduction.The magnitude caused due to effect depends on the type of the charge air systems. little amount of nitrogen oxide reductions reported with some diesel particulate filters system, usually in the range to 2-3% percent are possibly resulted by this effect. Large amount of exhaust pressures can increase the chances of failure of turbocharger seals of engine, which may results into oil leak of the exhaust system. In the systems with catalytic diesel particulate filters or other catalysts are used in the engine, such oil leak can also result in the catalyst deactivation by phosphorus and other catalyst poisons present in the oil. Maximum engines have an maximum allowable engine back pressure specified by the manufacturer of the engine. If an engine is run at higher speed and creates more amount of back pressure. Those type of standards result are normally accepted by automotive engineers that for every inch of Hg of back pressure (Mercury inches of Hg is a unit used for measuring pressure) nearly 1-2 HP of power lost depending on the displacement and efficiency of the engine, as well as the combustion chamber design etc .

6. Design Principle

Sound waves passing through the pipe can reduce the noise level by the use of dissipative or a reactive muffler. Reactive muffler use the principle of resonance to absorp the acoustic power. Reactive silencers, those are generally used in automotive applications, reflect the sound waves back towards the source and prevent sound from being pass to the pipe. Reactive silencer design is based either on the principle of aan expansion chamber or an Helmholtz resonator, and requires the use of sound transmission line theory. In a Helmholtz resonator type design a cavity is attached to the exhaust pipe. At a specific range of the frequency the cavity will resonate and the waves in the exhaust pipe are reflected back towards the source. In some designs, the muffler has several type of resonators of different sizes to focus a range of frequencies. Expansion chamber mufflers reflect waves by introducing a sudden change in cross sectional area in the pipe. They do not have the high attenuation of the Hemholtz resonator, but have a broadband frequency characteristic, with pass bands when half the acoustic wavelength equals the cavity length. The effect of flow is related to the interaction of sound with turbulence and will be dependent on the internal design of the muffler.

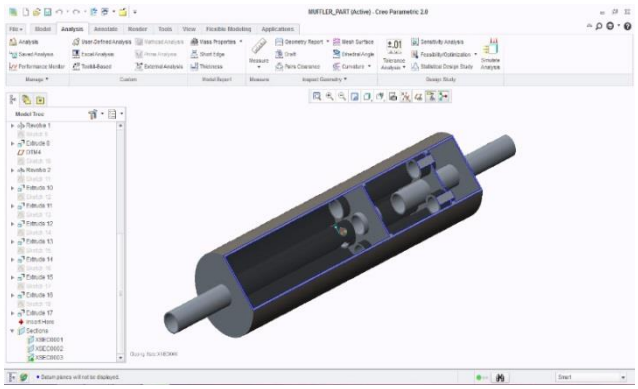

Fig 6.1 Cad-Model

6.1 Semi-active Muffler Designs

6.1.1. Benchmarking

Benchmarking is nothing but setting target. Here we are targeting the transmission loss.

6.1.2. Target Frequencies

After doing benchmarking exercise, there is needs to calculate the target frequencies to give more focus on higher transmission loss. For calculating the target frequencies engine max power rpm is required and calculation follows,

Theoretical Computation:

The exhaust tones are calculated using the following Formulae:-

CFR = Engine Speed in RPM/60.. For a two stroke engine (1)

CFR= Engine Speed in RPM/120-For a four-stroke engine (2)

EFR = n X (CFR) (3)

Muffler Volume Calculation Volume Of the muffler (Vm):-

Vm= Vf X [3.14/4(d2 X l)] X (No. of Cylinders/2) (4)

STEP 1: Benchmarking:

As per design methodology we benchmarked same kind of engine models to set the target of transmission loss of muffler.

Engine data: Hero Honda Splendor
Bore (D) = 55 mm
Stroke (L) = 54 mm
No. Cylinders (n) = 1
Engine power (P) = 6.15kw (8.36ps) @ 8000rpm
Max. RPM (N) = 8500 rpm
Allowable back pressure for muffler = Not available (in H2O) Transmission Loss Noise target

STEP 2: Target frequencies :

(muffler) = 30 dB.
To find fundamental frequency
Cylinder Firing Rate:-
CFR to be calculated as per the equation –2,
CFR =8500/120 = 70.83
Engine firing rate
EFR to be calculated as per the equation –3,
EFR = 1 x 70.83 = 70.83 Hz

STEP 3: Muffler volume calculation:

Swept volume (Vs): (3.14 x d^2 x L)/4= (3.14x55^2 x54)/4= 128294.79 x 10^-6 Lit.
Volume to be consider for calculation,
Volume = (n) x Vs/2 = 0.64
Silencer Volume =Factor x Consider Volume = 3.009Lit
Assumed Factor =4.7083

STEP 4: Internal configuration of muffler and concept design:

Diameter of muffler calculated as: Vm = (3.14/4) x D^2x L
0.00309x10^-6 = (3.14/4) x D^2x 0.54
D=0.097750 m
D=97.75mm (Diameter of muffler)

STEP 5: Selection of other parameters:

1. 3 chambers for good cancellation capacity
2. Inlet and Outlet extension : Not selected yet
3. Inlet and Outlet extension to be kept 180° reversal.
4. La= Length at which Perforation starts on pipe
5. Lb= Length at which perforation ends = Not selected.

Diameter of perforation: variable from 6mm to 11mm (referring to research paper) as seen below, for breaking of gas bubbles in different sizes.

A drain plug and refill cap is provided for replacement of water and maintenance.
A non-return valve is provided before perforated pipe to prevent water entering engine
Material : SS (Any grade depending upon its availability in market and its cost)

7. Scope

-Study the result of performance and analysis of working of exhaust system using semi active muffler silencer.
-Comparing the performance and working efficiency of muffler using exhaust system and semi active muffler using exhaust system and analysis of the results and uses.
-By using a semiactive muffler with number of sensors the exhaust noise can be easily tuned, amplified, or nearly eliminated.
- Can be used for Sports motorcycles, sports cars, ideal for a vehicle that has dual modes of performance for city and sporty use, vehicles designed for high fuel economy.

Conclusion

By studying and analysing the Semiactive muffler we can conclude that there is great amount of back pressure reduction when throttle starts to wide open. We can use engine with maximum fuel efficiency as the brake specific consumption is reduce considerably. The only effect is observed due to this system is the noise level is increased at the time of working of semi active muffler exhaust system.

References

M.P.Tambe (February 2016) - Analysis of exhaust system-semiactive muffler (International Journal of Innovative Research in Science, Engineering and Technology-February 2016)
Richard A. Craig (8 August 2013)-Noise reduction using a quarter wave tubes with different orifice geometries.(The University of Adelaide, South Australia 5005, Australia-8 August 2013)
Kashani R. - Low-frequency thermoacoustic instability mitigation usingadaptive–passive acoustic radiators. Proceedings of the ASME turbo expo, vol. 2.BC