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Reactive Silencer for Noise and Vibration Reduction: A Schematic Review

Shital R. Khaire[1], Dr. Anil S. Maheshwari[2]

[1]*M-Tech Student, Department of Mechanical Engineering, School of Engineering And Technology, Sandip University, Nashik, Maharashtra, India*

[2] *Professor, Department of Mechanical Engineering, School Of Engineering And Technology, Sandip University, Nashik, Maharashtra, India*

ABSTRACT –

With the increase in demand for electricity consumption day by day, there is a power shortage at remote places. In many power sources like in industries, household applications diesel generators are preferred, But these diesel generators causes large noise pollution. In order to meet the power demand in such places as in an agriculture field, the small generator sets are found to be the perfect solution. Generally, the small generator set does not follow the pollution guidelines as these are assembled to meet the requirement also because of noise produced; their use is limited to the non-residential area. Therefore in order to reduce the noise level of such a small generator set and to use the system everywhere, author tried to review the research papers of last two decades and progress in modifications of mufflers. This paper focuses on study of modified silencer to reduce backpressure.

Keywords*: Diesel Generator, Noise level, Pollution, Modified Silencer, Backpressure, etc.*

I. INTRODUCTION –

The waves which coming from vibrating body and reaches to ears of listeners, it is called as sound. When this sound appears unpleasant or causes irritation to listener then called as noise and that pollution is called as noise pollution. Sound is measure in desibel. Human can hear from 0 dB to 180 dB. Above 95 dB sound is comes under noise pollution. [2]

Automobile silencer or muffler is a device used for reducing the noise emitted by the exhaust of an internal combustion engine especially a noise deadening device forming part of exhaust system of an automobile. Mufflers are installed within the exhaust system of almost all internal combustion engines. The muffler is engineered as an acoustic device to reduce the loudness of the sound pressure created by an engine by acoustic quieting. The noise of

the burning hot gases exiting the engine at high speed is abated by a series of passages and chambers lined with resonating chamber harmonically tuned to cause destructive interface wherein apposite sound wave cancel each other. An unavoidable side effect of this noise reduction is restriction of the exhaust gas flow which created back pressure which leads to the decrease in engine efficiency. This is because the engine muffler must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler designed to mitigate.

To improve performance of muffler, need to focus on parameters like, Backpressure, Transmission loss, Pressure drop. Transmission loss is basically acoustic performance of the system. Usage of baffle in muffler increases result of transmission loss more than 40%. [15]

II. LITERATURE REVIEW -

In 2014, Rahul D. Nazirkar et al. [1] designed and optimized an exhaust muffler which has a working frequency different from the natural frequency so as to avoid resonance and hence reduce the noise. They concluded that Double expansion chamber gives better results as compared to single expansion chamber and that transmission loss of the muffler can be increased by adding protrusion pipe at inlet and outlet.

VidyaSagar and M.L.Munjal, [5] designed and analysis three pass double reversal muffler. By introducing tubular bridges in end chambers can help minimizing of free shear layer in the muffler, providing good acoustic transmission loss and further reduce backpressure.

In 2014, Shubham Pal et al. [6] designed a muffler using piston cylinder arrangement to change the resonator length. Tested it on 3-cylinder engine setup and concluded that if reduce the resonator size, insertion loss would be more and therefore reduced noise. The disadvantage is that cost required more for piston cylinder arrangement for variable resonator.

In 2014, Atul A, Patil et al. [3] by controlling the back pressure, designed exhaust system to improve the brake thermal efficiency. They concluded that there will be a reduction of the recirculation of zones, with the increase in pressure of flow when inlet cone angle is increased.

Ahmed Elsayed et al. [15] described the effect of baffle size on muffler backpressure and transmission loss. Multiple holes helps to reduce backpressure. It was found that centered hole more effective than distributing holes on surface of baffle plate also enhance the transmission loss by reducing the baffle spacing.

S. Rajadurai et al. [18] discussed the materials required for automotive exhaust system in details. Considered mechanical, Chemical, physical properties during selection of material.Explained the effect of additives in materials.

M.C. Chiu and Y.C. Chang [4] in their paper on muffler designing, published in 2011, explains their researches on side inlet or outlet type mufflers that has perforated tubes which are open ended. The designing is done using simulated annealing. In conjunction with a simulated algorithm, a 4- pole matrix system is derived in order to calculate the acoustic performance.

They concluded that mufflers with perforated tubes that intrude from expansion chamber to chamber is superior in performance of attenuation to a non-perforated tube. They showed that perforated or non- perforated open ended tube incorporated multi-expansion chamber mufflers together with surface algorithm optimizer can be efficiently incorporated or optimized into the given limited space using a 4-pole transfer matrix, plane wave theory and a technique of decoupling that is generalized. They found that a three chambered non perforated intruding pipe muffler and a two chambered perforated tube muffler possesses the same noise reduction capacity, showing us that perforated tubing's has more to do with noise attenuation .

SUMMARY OF RESEARCH PAPER -Author	**Title**	**Journal**	**Methodology**	**Remark**
M. Rahman et. Al [7]	Design and Construction of a Muffler for Engine Exhaust Noise Reduction	Proceedings of the International Conference on Mechanical Engineering	Various noise performance characteristics of muffler are analysed and compared with that conventional muffler	Resonator having working bandwidth of 110 Hz. The resonator largely ineffective when the residual frequency exceeds the range of this bandwidth.

Antonio Petosic et. Al [9]	Acoustic Performance of Parallel Baffled Silencers Different Configurations in HVAC Channel	Engineering and Applied Science	Measured parameters between artificial and real sound source to use less complicated in-situ measurement setup. Compared performance between absorptive and semi-reflective baffle.	Semi-reflective baffles are longer and so they are heavier. So performance of semi-reflective is better than absorptive baffles at low frequency.
Vaibhav Prajapati et. Al [10]	Design and Analysis of Automotive Muffler	International Journal of Engineering Research & Technology (IJERT)	The muffler designed to improve existing performance of muffler of maruti-suzukiWegon R car.	Increase in pressure loss will increase the backpressure which is not a desirable property of an automobile exhaust muffler.
Xiang Yu et. Al [11]	"Duct noise attenuation using reactive silencer with various internal configurations	ELSEVIER	To investigate separate effects of several typical silencer configurations. Compared with a simple expansion chamber.	Can enhanced the sound attenuation by combining the expansion effect, acoustic resonator effect and by improving the flow performance.
LalitZipre et. Al [12]	Design and Optimization of exhaust system for internal combustion engines	International Journal of Scientific & Engineering Research	studied various processes for designing process of exhaust system	Hardware configuration effect on the noise and flow characteristics.
Jashanpreet Singh et. Al	A Study on Effectiveness of Muffler on a Two-wheeler vehicle Noise	Noida Institute of Engineering	The effectiveness of muffler of two-wheeler vehicle.	The value of insertion loss increases with the increase in engine

[13]		& Technology (NIET)		speed.
Sandeep Yadav et. Al [14]	Mechanical Designing of Acoustic Chamber Based Muffler for Sound Reduction	International Journal of Engineering and Advanced Technology (IJEAT)	Design methods of mufflers	For better performance of attenuation, sound absorbing chamber is an efficient device.
Gnanendhar Reddy et. Al [17]	Design and fabrication of reactive muffler	International Journal of Chemical Science	Designed the muffler which fulfilled the requirements like more transmission loss, minimum sound, minimum backpressure, durability.	The designed muffler is capable to attenuate both high and low frequency noise.

III. SELECTION OF MATERIAL -

Depending upon warranty requirements, durability and regulatory compliances selection of material for exhaust system plays important role. Mainly it selected by considering parameters like internal corrosion resistance, external salt corrosion resistance, high temperature oxidation resistance, thermal mechanical vibration resistance with physical mechanical, chemical properties of material. [18]

Figure 1 shows the temperature distribution in exhaust system when using Diesel and Petrol in engine. Measure temperature drop seen between resonator to tailpipe.

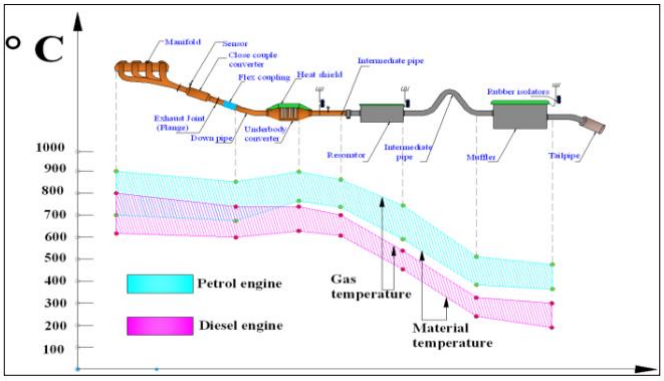

Figure1. The thermal histogram of the exhaust system for diesel and applications. [18]

Depending upon function of component of exhaust system, material to be selected. Table 1 shows material requirements depending upon function of component.

Components	Functions	Material requirement
Manifold	Low thermal mass and durability	SUS 429LM,441L,304
Catalytic convertor	Converts toxic gases into non-toxic gases	SUS 439L,430,441L
Flexible coupling	Withstands the vibrations coming-out from the engine and road	SUS 304,321,XM15J1
Muffler	Noise attenuation	SUH 409L,SUS 439L,SA1D
Flanges	Interlinking the exhaust system with pipes	SS400,SUH 409L
Pipes	Interlinking the exhaust system Component regulates the flow of gases.	SUH 409L, SUS 439L,SA1D
Hanger rod	Mounting the exhaust system with the chassis	S10C,STKM11A

Table1. Functions and material requirements of exhaust system components. [18]

Following parameters impacted on design of muffler:

1) Backpressure: Pressure created by muffler against flow of exhaust gas and impacted on engine efficiency of generator. So to avoid power loss minimize the backpressure. In reactive silencer, some changes created to change the direction of exhaust gas. So backpressure is more created in reactive silencer than absorptive type.[19]

2) Size: Size of muffler is depends on engine capacity and space availability.

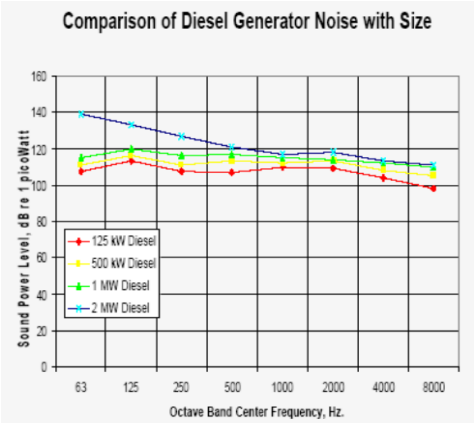

Figure 2 Comparision of Diesel Generator noise with size.[2]

Figure 2 shows with increasing power of Diesel generator , the sound power level also increases with their octave band center frequency.[2]

3) Transmission Loss (TL): Transmission loss can be calculated as:

TL= 10 $\log\left(\frac{An}{Al}\right) B1 = 0$

An = Episode weight waves amplitude in exhaust pipe

Al = Episode weight waves amplitude in tail pipe

B1 = Reflected weight waves amplitude in tail pipe [14]

4) Durability: Life of muffler should be good due to it is dealing with hot exhaust gases. This depends on type of material used and type of material used. There is loss in absorptive material in absorptive muffler due to clogging, need to change after some duration. Compared to absorptive muffler, life of reflective muffler is much good, performance of it remains same with changing time.[19]

IV. CONCLUSION AND DISSCUSION –

1) By referring lot of research paper it is concluded that by using above procedure, can design appropriate modifying muffler, material selection, using type of muffler depending upon application.
2) By controlling backpressure, reduce the noise level ultimately improve the efficiency of muffler.
3) Double expansion chamber gives better results compared to single expansion chamber.
4) Transmission loss of the muffler can be increased by adding protrusion pipe at inlet and outlet.

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