

# Attenuation of Noise, CO and HC Emission in Vehicle using Reactive Silencer

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**ABSTRACT:** Reactive silencers, which are commonly used in automotive applications, reflect the sound waves back towards the source and prevent sound from being transmitted along the pipe. Reactive silencer design is based either on the principle of a Helmholtz resonator or an expansion chamber, and requires the use of acoustic transmission line theory. Structure of current silencers involves a drawback which is essentially focused on the fact that silencers are large if they are to be acoustically effective, which in turn means that they are heavy in relation to the power of engines. More specifically, this problem is because current silencers require a large volume of air to be able to dissipate the frequencies generated by the exhaust gases from the engine. In this work, new silencer is designed using concept of reactive silencer and manufactured. Experiment is conducted on conventional and new designed silencer to measure noise, %CO and HC emission. Experimental result gives noise level of conventional and new designed silencer for various speeds and various loads. And it is found that noise is reduced due to glass wool absorptive material used in new designed silencer. Emission from exhaust gases produced in conventional and new designed silencer is measured in terms of % CO and HC and compared.

**KEYWORDS:** Reactive silencer, Helmholtz resonator, Noise attenuation.

## I. INTRODUCTION

Exhaust system is effectively a series of pipes and boxes specially designed to channel emissions away from the front of the vehicle, reduce engine noise and maintain optimum fuel efficiency. All exhausts produce 6 gases as emissions; of the six three are less harmful (nitrogen, carbon dioxide and water vapour) and three are toxic (carbon monoxide, nitrogen oxide and nitrogen monoxide). The job of the exhaust, catalytic converter and its monitoring system is to maintain the correct balance of emissions, check the engine is running efficiently and move the emissions away from the vehicle occupants. In this work, silencer is designed to attenuate noise, %CO and HC emission using reactive silencer.

F.D.Denia et al. [1], derived a finite element model for the acoustic analysis of perforated dissipative silencers with high temperature and thermal gradients in the presence of mean flow. The spatial variations of the temperature field have been shown to generate heterogeneities in the mean flow as well as in the properties of the sound propagation media (air and absorbent material). For the central passage, an acoustic velocity potential-based wave equation has been considered, valid for non-uniform mean flow and inhomogeneous fluid (air) with properties that vary with position. Concerning the outer chamber, the absorbent material has been modeled by its complex equivalent acoustic properties. Xiang Yu, et al. [2], proposes sub-chamber optimization for the design of a silencer. A theoretical basis is presented for a description of the overall transmission loss (TL) of the silencer, using the TLs of each of the cascade-connected multiple sub-chambers and the interactions between them. Three typical sub-chamber configurations are considered, representing the effects of varying geometrical parameters, adding internal partitions, and introducing perforated liners. The characteristics of the sub-chambers, influences of the parameters, and the limits of design are investigated to provide guidelines for optimization. Anant Wankhade et al. [3] propose a simple in construction, effective silencing device, which can achieve good results in minimizing the noise. The acoustic analysis is one of the methods which help to analyses the sound level at the tail pipe. This optimization revises acoustic analysis of muffler using Finite Element Analysis. The muffler is modeled in 'PRO E Wildfire 5.0' and 'COMSOL MULTIPHYSICS' is used for acoustic analysis. Effect of extrusion of inlet and outlet pipe inside

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the chamber and also the position of the extra inlet tube (i.e. divided inlet) to the chamber and then optimized this parameter to get the minimum sound pressure level (SPL) or maximum transmission loss (TL). Rogerio Cora et al. [4] evaluate the performance of the Helmholtz resonators to control acoustic instabilities inside combustion chambers. In this work, some tests were conducted with non-reactive flow inside the combustion chamber. A methodology to design the resonators and the calculations to theoretically determine the acoustic performance of damp instabilities, an experimental setup especially developed to study instabilities in reactive and non-reactive flows, and the experimental results for non-reactive situation with and without flow was presented in this paper. Vasile Ovidiu [5] investigates the acoustic performance of a reactive silencer for two special cases using numerical and experimental techniques. The plane waves based models such as the transfer matrix method (TMM) or boundary element method (BEM) can offer fast initial prototype solutions for silencer designers. The principles of TMM and BEM for predicting the transmission loss (TL) of a side-branch muffler are briefly presented. The method is applied for each silencer configuration and the numerical predictions are compared with the results obtained by means of an experimental setup. Soon-Hong Park [6] introduce micro-perforated panel absorbers backed by Helmholtz resonators to improve sound absorption in the low-frequency region where conventional micro-perforated panel absorbers cannot provide sufficient absorption. The neck of the backing resonator is designed to be extended into its cavity to reduce the total thickness of the proposed absorber. The acoustic impedance of the proposed sound absorber is investigated by using the transfer matrix method. G. Montenegro et al. [7] describes the development and application of different non-linear models: a coupled 1D-multiD model and a coupled 1D-quasi-3D model, to predict the silencer behaviour in the time and frequency domains. Second order time and space discretization were adopted in the 3D and quasi-3D approaches, whereas specific coupling strategies were developed to realize the interface between them and the 1D model. In particular, since the 3D relies on a collocated grid discretization, a Riemann solver based method was developed to realize the coupling with the 1D code, while a cell overlapping procedure was exploited to interface the 1D code with the quasi-3D method, in order to fit with the pseudo-staggered grid arrangement. Both a white noise and a single impulse boundary condition have been imposed upstream of the pipe system to excite the wave motion. The integrated 1D-multi D and the quasi-3D approaches were applied to predict the transmission loss of reactive and dissipative mufflers in which the pressure waves can be significantly non-planar, to point out the influence of higher order modes on the acoustical performance. The review paper of M.L. Munjal [8] deals with evaluating approximate source characteristics required for prediction of the unmuffled intake and exhaust noise, making use of the electro-acoustical analogies. Author discussed recent advances in the theory and design of double-tuned expansion chamber and the extended concentric tube resonators, transverse plane wave analysis of short elliptical end chambers, acoustical source characterization of the intake as well as exhaust systems of reciprocating internal combustion engines, analysis of multiply-connected element mufflers, breakout noise of non-circular muffler shells, and analysis of diesel particulate filters and inlet air cleaners. An equally important design parameter is the mean pressure drop or back pressure, which has been mentioned.

Paper is organized as follows. Section II describes schematic of reactive silencer and working of the same. After design and manufacturing the silencer, experiment is conducted to measure noise, %CO and HC emission that is given in Section III. Section IV presents experimental results showing results of conventional and new designed silencer tested. Finally, Section V presents conclusion.

## II. RELATED WORK

Reactive silencer is designed in this work. Fig. 1 shows the schematic of reactive silencer and its working is described as follows.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

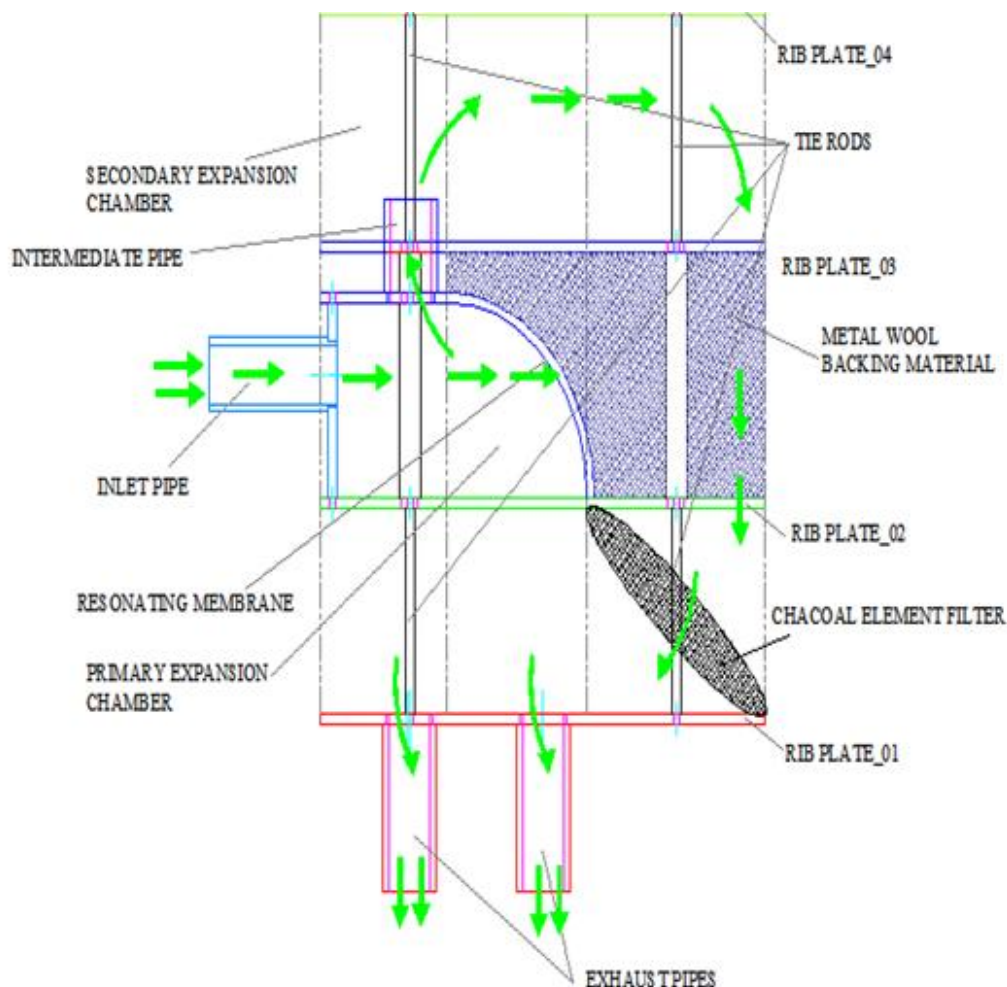


Fig. 1. Schematic representation of reactive silencer

An exhaust silencer for automobile vehicles, of the type incorporating a casing determining a gas tight chamber, based on a tubular frame and two end covers, and of those having a gas intake pipe and at least one outlet pipe for such gases, characterized in that the gas intake is located in the middle area of the tubular frame, said intake opening out into an expansion chamber, on the back wall of which the gases collide, which back wall being carried out in a multi-resonating membrane outside of which the chamber formed by the casing is filled in this area with an absorbent material, two outlet pipes being arranged on one side of the mentioned intake, perpendicular thereto and connected therewith through the mentioned expansion chamber, which outlet pipes internally house respective high frequency multi-resonators, whereas a Helmholtz resonator neck is arranged opposite to said outlets which opens out into an anti-resonating chamber located opposite to the gas outlets. An exhaust silencer for automotive vehicles, characterized in that arranged between the multi-resonating membrane and the absorbent material there is a layer of steel wool stabilizing said absorbent material, also having provided that this absorbent material also surrounds both the outlet pipes and the resonator neck. An exhaust silencer for automotive vehicles, characterized in that the empty anti-resonating chamber affects a little less than half the casing opposite to the outlet pipes, said anti-resonating chamber together with the resonator neck defining a dampener for the frequencies causing noise that bothers the ears, while at the same time the multi-resonating membrane filters high and middle frequencies as the gases collide on it. The charcoal filter acts as active carbon absorber that frees the exhaust gases discharged to atmosphere of carbon particles suspended as soot in the exhaust gases. Fig. 1.2 shows the new designed and manufactured silencer.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016



Fig. 2. Photograph of new designed and manufactured silencer

New design silencer Fabricated from Casing Pipe, Charcoal pipe 1, Charcoal pipe 2 all made up of Material Composition of SA 312 TP 316 L and Resonating membrane of Brass material is used.

## III. EXPERIMENTAL WORK

Experimental trials are carried out on conventional and modified silencer with application of 2-stroke petrol engine to measure noise level, emission (in terms of % CO and HC) from engine. Noise and emission measurement requires several instruments. Sound level meter is used to measure noise level, Digital tachometer for measurement of speed and Emission Analyzer is used for emission measurement. Fig. 3 shows experimental setup with new modified silencer.

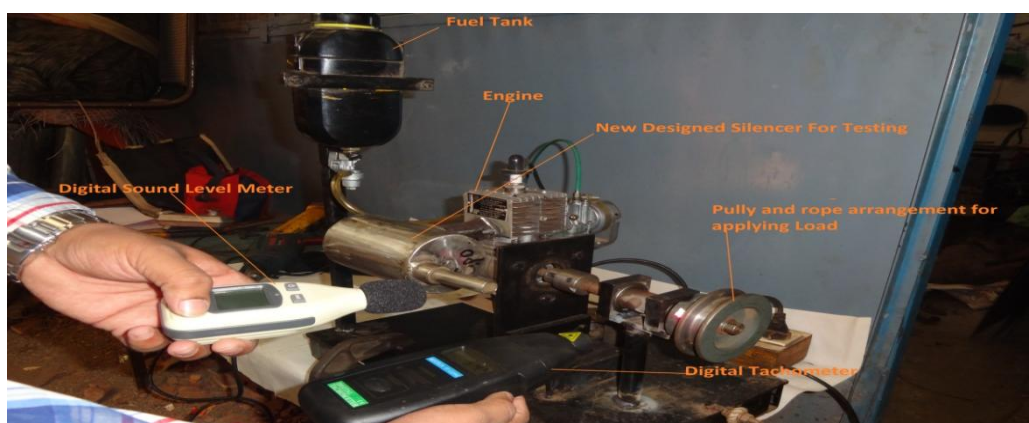


Fig. 3. Experimental setup with modified silencer for noise measurement

First, firmly fix the setup on table with C-Clamp. Connect the modified silencer at engine output. Then switch on the fuel supply to engine and start the engine. At no load measure speed with digital tachometer and noise with sound level meter as shown in Fig. 3. Repeat the measurement of speed and noise for different loads i.e. 0.5, 1, 1.5, 2.0, 2.5 Kg. The %CO and HC emission from silencer is measured with four gas analyser for different load. The same experiment is carried out by connecting conventional silencer on engine and results of noise, %CO and HC are noted.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

## IV. EXPERIMENTAL RESULTS

The results of experiment are tabulated in Table 1 and Table 2 for conventional and modified silencer respectively.

Table 1. Experimental results of Noise, % CO and HC at different loads and speeds with conventional silencer

Load(Kg)	Speed (RPM)	Noise (dB)	%CO	HC (ppm)
0	4100	119	1.3	560
0.5	4000	120	1.32	595
1	3750	123	1.36	635
1.5	3550	125	1.41	656
2	3400	128	1.47	678
2.5	3180	129	1.51	710

Table 2. Experimental results of Noise, % CO and HC at different loads and speeds with modified silencer

Load(Kg)	Speed (RPM)	Noise (dB)	%CO	HC (ppm)
0	4100	82	0.78	360
0.5	4040	85	0.89	395
1	3850	88	0.96	431
1.5	3810	91	1.09	454
2	3780	95	1.17	472
2.5	3760	98	1.24	516

Figure 4 depicts the difference in Noise level of Conventional and Modified silencer and shows that Noise obtained by application of modified silencer is less than noise obtained by conventional silencer.

# International Journal of Innovative Research in Science, Engineering and Technology

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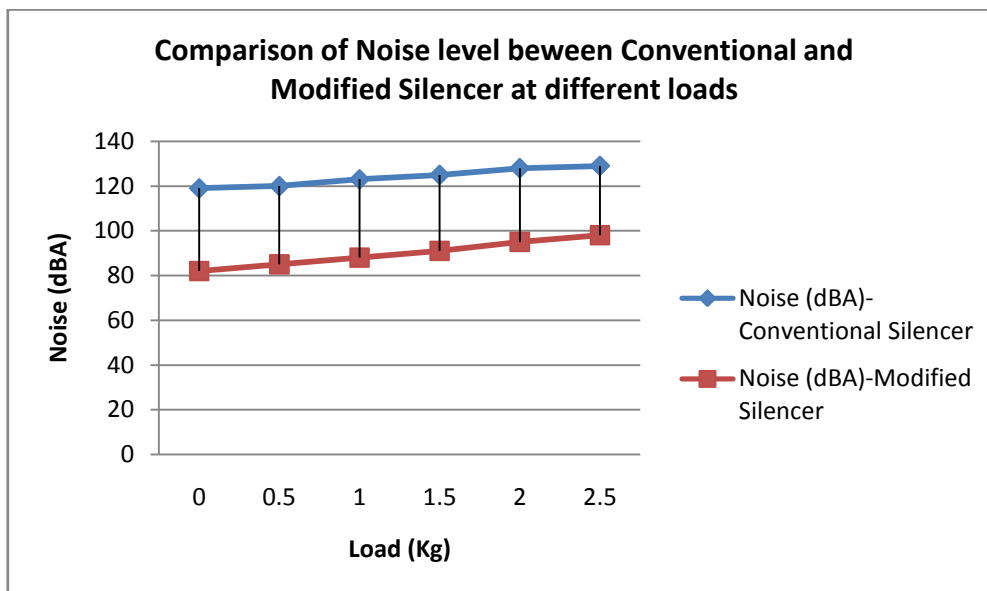


Fig. 4. Noise V/s Load for Conventional and Modified silencer

Figure 5 represents the difference in percentage of CO with Conventional and Modified silencer and it is concluded from this figure that, percentage of CO obtained by application of modified silencer is less than percentage of CO obtained by conventional silencer.

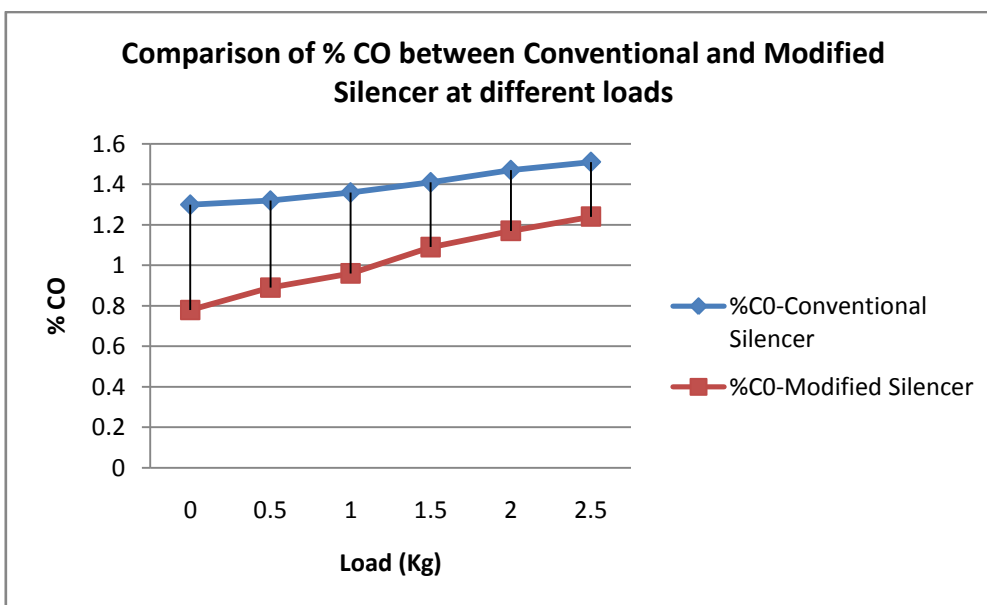


Fig. 5. %CO V/s Load for Conventional and Modified silencer

Figure 6 shows the difference in percentage of CO with Conventional and Modified silencer and it is determined from this figure that, HC emission obtained by application of modified silencer is less than HC emission obtained by conventional silencer.



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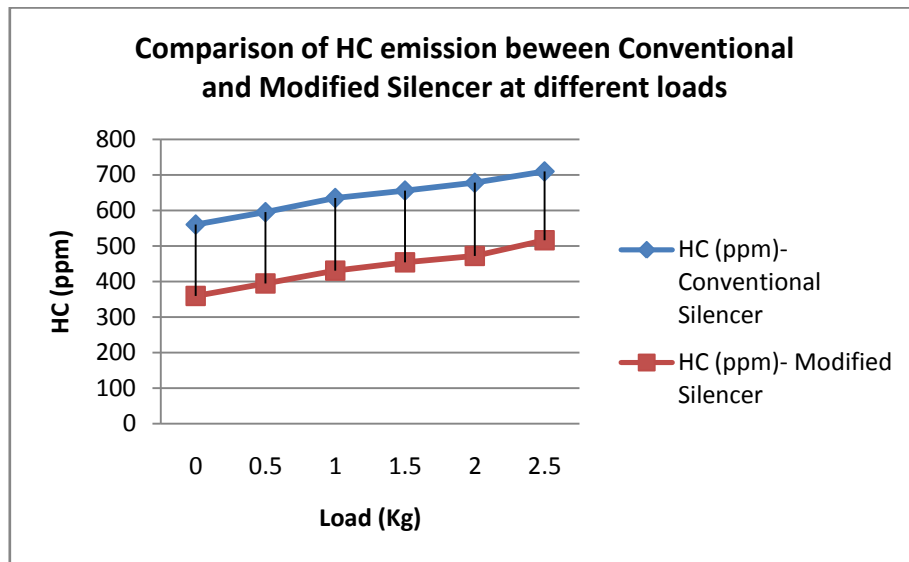


Fig. 6. HC V/s Load for Conventional and Modified silencer

Figure 7 displays the difference in Engine Speed with Conventional and Modified silencer and it is strong-minded from this graph that, engine speed obtained by application of modified silencer is improved as compared with speed of engine when conventional silencer is used.

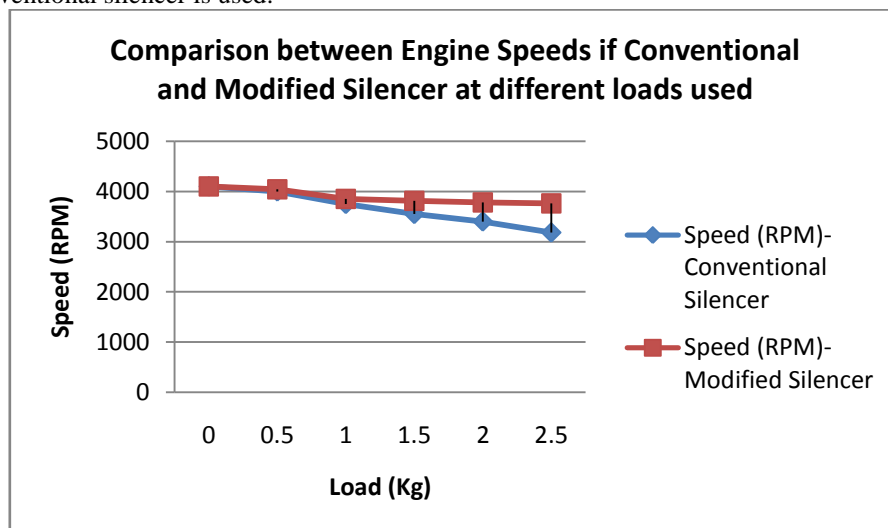


Fig. 7. Speed V/s Load for Conventional and Modified silencer

## V. CONCLUSION

The experimental result provides the noise level results of conventional and new designed silencer. From the results obtained by trials, it is evident that Noise level is reduced by 30-40 dB when new designed silencer is used. And also %CO and HC emission from the designed silencer are reduced by 0.2-0.45 % and 190-210 ppm respectively. It is also perceived from the results that speed is improved though load increased, which shows performance of engine is improved with new designed silencer. Therefore, it can be said that noise, CO and HC emission is attenuated in vehicle using new designed reactive silencer.

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