

Experimentation of Emission Control on a Four Stroke Diesel Engine using an Eco-Friendly Silencer with Excess Air



A. Dhanalakshmi, M. Suresh, A. Ravinthiran, P. Pradeep kumar, A. Saleem

Abstract - Earth is suffering a lot due to Air pollution and degradation, we are in a position to save the earth from this. For that an invention should be made to prevent the earth. Even though a lot of pollution are happening in and around the earth, Air pollution seems to be a dangerous one. The main sources of air pollution are exhaust gases that is coming out of Automobiles and Industries. Taking this in mind, an invention has been found to overcome and reduce the exhaust gas that is coming out from engines. A typical silencer (Eco friendly Silencer) has been made to filter the pollutants that are coming from automobiles. After installing this silencer, the gases like NO_x, CO, sulphur are analysed. This analysis is made using five gas analyser, and reduction of pollutants are measured periodically. After analysis, it is found that the noise and smoke level are reduced a lot. So this silencer will definitely been a tremendous invention to reduce pollutants. When compared to other silencer, this silencer is much cheaper, easy to install and no need of any Catalytic convertor. After making some improvisation, this silencer can also be used in Industrial Engines.

Keywords: Pollution, Exhaust gases, Invention, Gas Analyser, Catalytic convertor, Eco Friendly silencer.

I. INTRODUCTION

Now a day's automobiles are very essential needs of human beings. Our world without automobiles is unimaginable today. The use and dependent of automobiles is increasing day by day, but with the exhaust gases coming out from the automobiles become major constituent to air pollution. It is found that every human being is inhaling about 17 to 24kg of air every day. Inhaling the polluted air may affect the health and causes illness to the humans and animals also. Hence it is necessary to control the emission coming out of the engine exhaust instead, of reducing the usage of automobiles which is undesirable and not appreciated. Another major threat is Global warming which poses serious threat to quality of

ozone layer that is degrading at a faster rate. Gases responsible for global warming are CO, CO₂, Oxides of nitrogen, oxides of sulphur and unburnt hydrocarbons. Activated carbon, ceramic rings, activated alumina are greatly absorb the carbon particles and smoke particles and trapped in these materials. Limestone is used to absorb the sulphur particles and Soda lime is used to prevent NO_x particles from letting it out to atmosphere. Perforated tube and Glass wool are used to reduce the noise level of the silencer because, these are very good noise dispensers. Composition of the normal engine exhaust are Nitrogen (71% of vol.), Hydrocarbons (<0.25% of vol.), Oxides of sulphur (<0.03% of vol.), Carbon dioxide (14% of vol.), Water vapour (12% of vol.), Oxides of nitrogen (<0.25% of vol.), Carbon monoxide (1-2% of vol.)

B. Things to be taken care of before starting to fabricate:

Sources of Air pollution

1. Automobiles
2. Thermal power plants
3. Industries
4. Refuse burning
5. Industrial processing
6. Natural disasters

Sources of air pollution

1. Carbon monoxide (CO)
2. Carbon dioxide (CO₂)
3. Unburnt hydrocarbons (UBHC)
4. Oxides of nitrogen (NO_x)
5. Oxides of sulphur (SO_x)

II. CONSTRUCTION DETAILS

A. Construction

The silencer used for fabrication is purchased from outside and cut open as shown in figure 2. The Internal components in the muffler part is removed and it is made to have hollow cavity. The steel pipe channels are made and each of them are 14 inches in length, four in number and has about 25 slots in to allow the exhaust gas to freely pass through these channels(1). These channels are welded using gas welding in the form of radial arrangement. Then the chemical components are filled inside these channels in their respective slots. Perforated tube is then welded to the nozzle and the nozzle is again welded with the muffler part, such that the radial arrangement and the perforated tube appears at the centre when looked from the other side.

Manuscript published on November 30, 2019.

* Correspondence Author

A.Dhanalakshmi*, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.

M.Suresh, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.

A.Ravinthiran, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.

P.Pradeep kumar, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.

A.Saleem, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Experimentation of Emission Control on a Four Stroke Diesel Engine using an Eco-Friendly Silencer with Excess Air

Now, the glass fibre wool is then stocked in between the gaps of perforated tube and the channels as shown in figure 3. Now the rear end which has the non-return valve is welded to the rear end of muffler. Then the whole setup is then welded and clamped to the two-wheeler as shown in figure 1.



Figure 1. View of muffler hollow cavity



Figure 2. Glass fibre wool



Figure 3. Rear end welded after stocking

III. COMPONENTS

Activated charcoal: After heating charcoal for several hours, its surface area will get increased. This charcoal is now called as activated charcoal. This is shown in figure 4. This charcoal is highly porous. So, the charcoal is a good absorbing medium. Hence the gases may purify. Many different types of charcoal are available. But activated carbon charcoal is commonly used as an effective filter medium is silence. Charcoal may be activated to increase its effectiveness as a filter. Activated charcoal readily adsorbs a wide range of organic compounds dissolved or suspended in gases and even liquids. It has the pore diameter of about 2 to 40nm which is

mesopores. This activated charcoal is filled in the radial channels.



Figure 4. Activated carbon pellets

By de-hydroxylation of Aluminium hydroxide we get activated Alumina which is a highly porous material which is shown in figure 5. It is a Solid form aluminium oxide. It has a very great surface area. Activated Alumina tends to clean the environment. One of the important features is that it is very much stable. In many industries for water purification this type of activated Alumina is used.



Figure 5. Activated alumina balls

Ceramic Rings: Ceramic Rings are Very Porous, Although They Look Solid, There Are Zillions of Tiny Holes in It, And That Makes It an Ideal capturing the smoke particles that you want in the filter(2). Ceramic Rings Are Extremely Porous as shown in figure 6, Which Provides A Lot of Surface Area for small particles to entrap in it. Ceramic products are much cheaper than others.



Figure 6. Highly porous ceramic Rings

Calcium hydroxide is commonly called as Limestone. It is dissolved in the water to form lime water. Normally the lime water is colourless which is shown in figure 7. The dissolved water should be pure water and it should be filtered after dissolving limestone into it. Lime milk is obtained when excess of calcium hydroxide is added. Nitrogen getting absorbed from exhaust gases by Limestone.(3)



Figure 7. Lime pellets

Soda lime: The most common absorber is Soda Lime. The Soda Lime can be formed using a mixture of chemicals in granular form kept in a closed environment as shown in figure 8. The environments can be compression chamber, rebreathers, submarines, etc. This kind of Soda Lime mainly absorbs oxides of Nitrogen.(4)



Figure 8. Sodallime

Glass wool: It is made of glass fibre. These fibres are bonded together using some binder which may be in the form of wool as shown in figure 9. This can be mainly used for insulation purpose. In this the Glass wool place a major role.(5,6)



Figure 9. Glass fibre wool

Stainless steel pipe: Stainless steel pipe is cut and made into small channels, each of 14 inch in length and are made four in number and has 25 slots to allow the exhaust gas to pass through these channels for effective absorption as shown in figure 10.

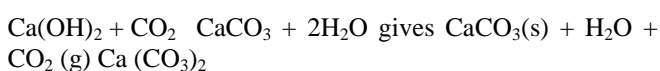


Figure 10. Slots made in stainless steel pipe

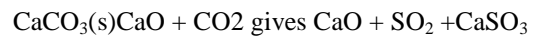
IV. CHEMICAL REACTION

Limestone pellets:

1. When CO₂ is filled inside the muffler area, the following reaction takes place:

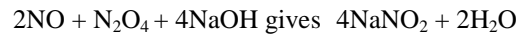


2. Calcium carbonate decomposes above 400 degree celcius to form calcium oxide and carbon dioxide. Calcium oxide reacts with Sox resulting in formation of calcium sulphite(8).

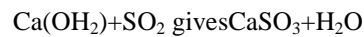


Soda lime:

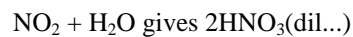
1. The following reaction takes place when Nitric oxide absorbed with nitrogen dioxide.



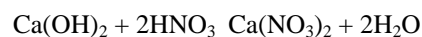
2. The following reaction takes place when sulphur is released in exhaust gas. Resulting in formation of calcium sulphite which is harmless compound that is precipitated and naturally degrading property(1) .



3. The water by product will be in the form of steam due to high temperature in the silencer. This helps in absorbing the Nox effectively(12).



These dilute acids reacts with Calcium hydroxide



V. WORKING

The Engine setup is shown in the figure 11. Here a 3 stage electric air pump is provided to inject air into the exhaust manifold. This is done during its cold start so as to provide excess air during starting. Maximum flow rate is 620 litre/min. Lot of test is conducted by varying injection rate. The injection rate of 350 litres/minutes seems to be good for better performance(7). Air is distributed through air rail which is of diameter 2.55 cm.



Experimentation of Emission Control on a Four Stroke Diesel Engine using an Eco-Friendly Silencer with Excess Air



Figure 11. Engine setup

Table.4. Engine details

General detail: Single cylinder, water cooled compression ignition engine

| | |
|-------------------------|--------------|
| Make | Kirloskar |
| Cubic capacity | 661 cc |
| Bore | 87.5mm |
| Stroke | 110mm |
| Compression ratio | 17.5:1 |
| Speed | 1500 rpm |
| Rated power | 4.4kW |
| Dynamometer | Eddy current |
| Cooling system | Air cooling |
| Nozzle opening Pressure | 200 bar |
| Injection timing | 23 [°CA] |

During the exhaust stroke the exhaust gases are forced to move out of combustion chamber into the silencer pipe in form of large air molecules. When the large molecule passes through the nozzle of the muffler through perforated tube which breaks down the large molecules of gas into medium gas molecules thus reducing the noise primarily(8). There we have kept a gasket metal filter to break down the molecules even smaller. Now the exhaust gas gets completely filled in the muffler and it passes into the channels through the slots provided in those channels. The respective gases are absorbed by the respective chemical components in the four channels provided. The glass wool provide in between the gaps of perforated tube and channels, is used to filter the smoke particles and it is a great noise silencer. In order to reduce the noise of the silencer to great extent secondary gasket filter is used at the rear end of the muffler. Now the filtered exhaust gas pass through the pipe at the rear end of muffler and out to the atmosphere(9-10).

By using the perforated tube throughout the length of muffler and sufficient space for the exhaust gas to flow freely in the muffler part we were able to maintain the backpressure constant so, that vehicle does not get turned off while running in idle condition(11) . We also placed the muffler with slight inclination towards the sky so, gases could come out to

atmosphere much easier. This vehicle is good to go in real time conditions also.

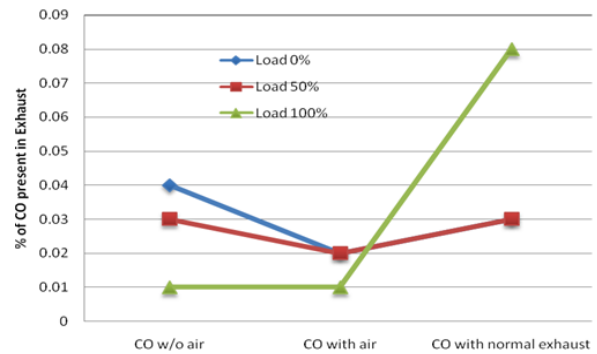


Figure 12. Percentage of CO present in Exhaust

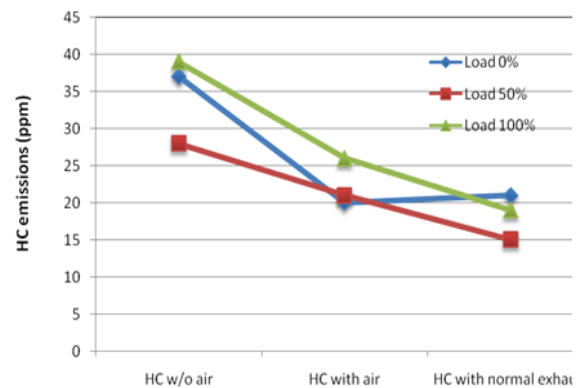


Figure 13. HC Emissions

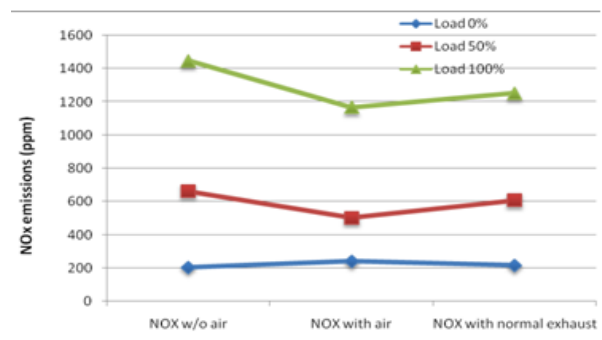


Figure 14. NOx Emission

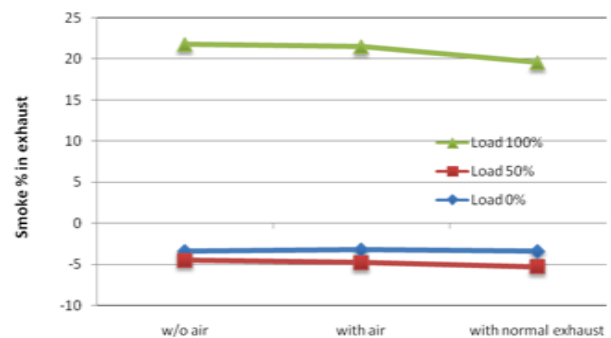


Figure 15. Smoke percentage in exhaust

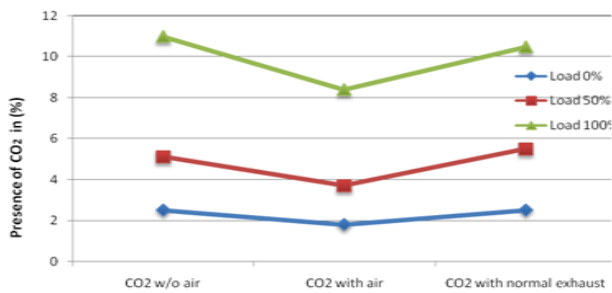


Figure 16. Percentage of CO₂ in exhaust

- It is found that the carbon monoxide gets reduced from 0.08% to 0.01% in newly designed catalytic converter. Shown in Figure 12.
- The presence of HC in our device is higher than the existing device. But when supplying additional air into the device which reduces the HC level comparatively. Shown in Figure 13.
- It is found that the NO_x has reduced from 1448 to 1167 ppm in full load condition. Shown in Figure 14.
- The percentage of oxygen has increased from our newly designed device's exhaust, by injecting constant pressure air into the device.
- By injecting air into the device, the presence of CO₂ gets reduced. Without injecting air in to the device it is almost as same as the normal exhaust. Shown in Figure 16.
- The smoke percentage of our device is little more than the existing device. But the difference is very negligible. Shown in Figure 15.

Still further design modifications are required since, our fabricated model is welded at the back end it is difficult for replacement of the Particles and components kept inside the muffler. By modifying the design it becomes easy for replacement of the particulars inside the muffler. The whole radial arrangement can be made like a single setup so, it can be replaced similar to replacing the filter in RO water purifiers.

A. Advantages:

- The emission of Carbon Dioxide has been reduced drastically.
- Maximum Control emission.
- Vibration free during engine running.
- Reduce Noise pollution getting reduced.
- No need catalytic convertor
- Very light in weight.
- Easy to manufacture.
- Cost wise low.

B. DISADVANTAGES:

The Limestone pellets, activated alumina, activated carbon, ceramic rings require replacement for a period of every 6-8 months.

VI. FUTURE SCOPE

We look forward that this project have lot of wide scope in every aspect because, in todays world each and every house atleast one person is observed to use motorcycle or cars , propably two in some houses. We also know that global warming is taking place at very fast rate, which causes depletion of ozone layer and reduces the purity of the air that we all breathe, as we could feel the drastic rise in temperature of surface and melting of very large Glaciers in Antartic regions is posing a serious threat to wild life in there. Large parts of world has already started to feel the scarcity of water, hence it is necessary that it is our responsibility to reduce and control the emission. So we thought that, any project based on emission Control will be appreciated with open arms.

VII. CONCLUSION

When compared to other silencer this eco friendly silencer is more effective. The emission of gases is getting controlled at a greater level. This is mainly possible since we used some of the components like Soda lime, activated charcoal, etc. The emission control test are conducted successfully and results has been shown clearly in the graph. Finally it is observed that the carbon dioxide emission is controlled in a greater level.

REFERENCES

1. Alen. M. A, Akshay. M, Prem sankar. R, Mohammed shafeeque. M "Fabrication and Testing of Aqua silencer", International Research Journal of Engineering and Technology, Vol. 2, Issue , August 2015.
2. Ishibe T, Santo T, Hyhashi T, Kato N, and Hata T, "Absorption of nitrogen dioxide and nitric oxide by soda lime, Journal of Anaesthesia, Vol. 75, 1995, 330-33.
3. Majeed J. G, Korda B, & Bekassy Molnar E. "Comparison of the efficiencies of sulfur dioxide absorption using calcium carbonate slurry and sodium hydroxide solution in an ALT reactor" Gas Separation and Purification, 9(2), 111-120.
4. Vikash R Agrawal. "Activated Carbon as Adsorbent In Advance Treatment of Wastewater." IOSR Journal of Mechanical and Civil Engineering, 2017, 36-40.
5. P. Balashanmugam, G. Balasubramanian "Design of Emission and Noise control device (Aqua silencer)", International Journal of Modern Trends in Engineering and Research, Vol. 2, Issue 1, Jan 2015.
6. Sarath Raj, Ajbin K Aniyam, Akshay Aji, Anandhu Raj, Anandu Mohan, Sharon T.R, "Fabrication and Testing of Portable Twin filter Aqua silencer", International Journal of Mechanical and Industrial Technology, Vol. 3, Issue2, October 2015.
7. J.Soundhar, R.Rastrapathi, S.Sugavanam, M.Venkatesan, "New Trends of Emission Control System Used In Silencer", International Journal on Application, August 2015.
8. Ardiani Y, Dwi T, Achmad T, "Reduce the concentration of carbon monoxide from mainstreams cigarette smoke by using coconut shell activated carbon filter". International Journal of Current Research, 2016.
9. A.Ravinthiran, D.K.Jayanth Naidu, S.Hareesh, N.Gurusubramani, K.S.Athvaith Muthukumar, "Investigation of Heat Dissipation between Dimple and Normal Silencer made of Chrome Steel", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-1S2, May 2019
10. Kurooka J, "Removal of nitrogen oxides from flue gases in a packed column", Environment Protection Engineering, Vol. 37 (1), 2011, pp. 13-22.2.



Experimentation of Emission Control on a Four Stroke Diesel Engine using an Eco-Friendly Silencer with Excess Air

11. Rishikesh Acharekar, Digvijay Bhujbal, Omkar Bhingole, Nitin Sherkar, Prof. Argade R.R. "Design, Development and Experimentation of Aqua-Silencer for Four Stroke Petrol Engine " International Research Journal of Engineering and Technology (IRJET), Volume:03 Issue:04, e-ISSN: 2395 -0056, p-ISSN: 2395-0072, April 2016.

AUTHORS PROFILE



Mrs. A.Dhanalakshmi is Assistant Professor in the Department of Mechanical Engineering of Sri Sairam Engineering College, Chennai. He has Teaching Experience of 10 years in the area of Thermal Engineering.



Mr. M.Suresh, working as Professor in Mechanical Department of Sri Sairam Engineering College, Chennai, Tamil Nadu, India. Having 28 years of experience in the field of Thermal Engineering.



Mr.A.Ravinthiran, working as Assistant professor in Mechanical Department of Sri Sairam Engineering College, Chennai, Tamil Nadu, India. Having 8 years of experience in the field of Engineering Design and Analysis.



Mr. P.Pradeep Kumar, Under Graduate Scholar in Mechanical Engineering of Sri Sairam Engineering College, Chennai, Tamil Nadu, India. Currently doing Post Graduate at UNSW, NSW, Sydney.



Mr. A.Saleem, Under Graduate Scholar in Mechanical Engineering of Sri Sairam Engineering College, Chennai, Tamil Nadu, India. Currently working in Universal Glass and Aluminium (UNIGA), RAK – UAE as Quality and Technical Engineer.