

Fabrication and Experimentation of Aqua Silencer

Vinay D R¹, Vijay Kumar S L², Sandeep K³

¹Department of Mechanical Engineering, New Horizon College of Engineering, vinaydr1986@gmail.com

²Department of Mechanical Engineering, Presidency University, vijaykumar1hassan@gmail.com

³Department of Mechanical Engineering, BNM Institute of Technology, sandipme27@gmail.com

Abstract— Air pollution is the introduction of chemicals, particulate matter or biological materials that cause harm of discomfort to humans or other living organisms or cause damage to environment. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet. The important pollutants involved are carbon monoxide, lead, hydrocarbons, nitrogen oxides, etc.

The main reason for air pollution being the exhaust of the engine. The power to move a vehicle comes from burning fuel in an engine. Pollution from vehicles comes from by-products of this combustion process (exhaust) and from evaporation of the fuel itself. The stationary engines in heavy industries also are the source of pollution. The necessary steps must be taken in the direction to control emission.

This work is an attempt to control the emissions caused by the engine exhaust using charcoal and water. The unit developed is fitted to the exhaust of the system. The sound produced under water is less audible than it produced in atmosphere. The charcoal absorbs the exhaust gases there by bringing down the emission caused by the engines. This is simple cheaper and easy to install unlike the conventional catalytic convertor. The smoke coming out of the exhaust of an engine is also a source of emission hence we have aimed at reducing the amount of smoke entering the atmosphere by a considerable amount.

Keywords— Pollution, Emission, Charcoal, Combustion, Perforated Tube

I. INTRODUCTION

Air pollution is most important from the public health point of view, because every individual person breathes approximately 22000 times a day, inhaling about 15 to 22 Kg of air daily.

Polluted air causes physical ill aesthetic and physiological effects. Air pollution can be defined as addition of pollutants to atmosphere, which will have an adverse effect on life upon our planet. The main pollutants contributed by automobiles are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOX) and Lead.

Transportation vehicles are not the only source of air pollution, other sources such as electric power generating stations, industries and processing units etc. also contribute heavily to contamination of our environment, so it is imperative that serious attempts should be made to conserve earth's environment from degradation. An aqua silencer is an attempt in this direction; it is mainly dealing with control of emission and noise.

An aqua silencer is fitted to the exhaust pipe of the engine. The decibel level of sound produced under water is less than it produced in atmosphere. This is mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level (30 to 40 decibel). This property of water is used in this silencer and hence its name AQUA SILENCER. The noise and smoke level are considerably less than the conventional silencer, it is cheaper, no need of catalytic converted and easy to install.

A. AIR POLLUTION

Air pollution can be defined as addition to our environment of any material which will have adverse effect on life and planet is called as air pollution.

The main pollutants from automobiles are Carbon Monoxide (CO), Unburnt hydrocarbons (UBHC), Oxides of nitrogen (NOX), Lead and other particulate materials.

B. THE POLLUTANTS FROM THE PETROL ENGINE

UNBURNT HYDROCARBONS

These are the unburnt gasoline vapour coming out of the exhaust pipe. The main reason behind this is the incomplete combustion of the fuel, evaporation of the fuel from carburettor and crankcase blow by which depends on the combustion chamber design [1].

C. CARBON MONOXIDE

Main reasons for carbon monoxide emission in the exhaust gasses are incomplete combustion of fuel insufficient supply of air and insufficient time available for the complete combustion [1].

D. OXIDES OF NITROGEN

They are combination of nitric acid and dioxide. Increased combustion of fuel rises the temperature and this increased temperature produces more oxide of nitrogen. Main factor which affect the formation of oxides of nitrogen are combustion chamber temperature. Therefore, high temperature and availability of oxygen are the two main reasons for the formation of NOX. The maximum NOX is formed at ratios between 14:1 and 6:1. At lean and rich mixture the NOX concentration is comparatively low [1].

E. GASOLINE ENGINE EMISSION

Mainly there are three sources of air pollution due to gasoline engine.

Table 1: Gasoline Engine Emission

Types of Pollution	Reason
Exhaust emission	Incomplete combustion
Evaporative losses	Direct evaporation from fuel supply system
Crankcase blow	Leakage of high pressure gasses into crankcase

F. EXHAUST EMISSION

The exhaust emission contains 3 specific substances, which are accounted for air pollution.

G. UNBURNT HYDROCARBONS (UBHC)

Hydrocarbons are mainly due to unburnt fuel vapour coming out of the exhaust because of

Table 2: Unburnt Hydrocarbons

Reasons	Implication
Short circuiting of fuel (escape of fresh charge from the exhaust during scavenging)	<ul style="list-style-type: none"> • Harmful to plant and crop • Forms smog blanket • Toxic when inhaled

H. CARBON MONOXIDE (CO)

Carbon Monoxide is mainly due to

Table 3: Carbon Monoxide

Reasons	Implication
Incomplete combustion (mainly due to deviated air fuel ratio)	<ul style="list-style-type: none"> • Toxic when inhaled • Prevents absorption of oxygen in blood

I. OXIDES OF NITROGEN (NO_x)

Oxides of Nitrogen is mainly due to

Table 4: Oxides of Nitrogen

Reasons	Implication
High temperature and availability of the oxygen and nitrogen as they react at high temperature	<ul style="list-style-type: none"> • Causes irritation to eyes and throat. • He+NOX in the presence of sunlight can produce a dangerous chemical called PAN (peroxy aceto nitrile).

J. EMISSION OF LEAD

Emission of lead is mainly due to

Table 5: Emission of lead

Reason	Implication
<ul style="list-style-type: none"> • Lead addition (tetra ethyl lead) is mainly to increase the octane rating of the fuel • Inhibit tendency to knock. • Provides micro cushioning to the valve at valve seat. • Allow high compression ratio 	<ul style="list-style-type: none"> • It can cause problem of blood circulation. • It blocks the pores and cover the pores of the catalyst in catalytic converter thereby creating problem. • Harmful effect on child growth and intelligence. • Liver and kidney damage, abnormalities in fertility and pregnancy.

K. EVAPORATIVE EMISSION

About 30% of total HC emissions occur from fuel tank line and carburettor

Reasons:

- High temperature.
- Fuel volatility.
- Location of fuel tank

L. CRANKCASE BLOW BY GASES

Leakage of air-fuel mixture and burnt gases through the piston and cylinder to crank case. Blow by gases = 85% of HC + 15% of burnt gases [1].

Table 6: Crankcase blow by gases

Reasons	Implication
<ul style="list-style-type: none"> • Air-fuel mixture trapped in the top land clearance and behind the top ring is unable to burn due to wall quenching effect, this trapped gas will be passed to the crank case through piston and cylinder clearance. 	<ul style="list-style-type: none"> • Unless the blow by gases is cleared from the crankcase it will cause trouble by forming sludge's and acids in the crankcase. • Sludge's will clog the oil lines and makes the lubrication system starving. • Acids will corrode the metal parts.

M. DIESEL ENGINE EMISSIONS

- Main culprit is particulate matter, sulphur and nitrogen oxide.
- Sulphur particulars < 10 microns in size are tiny enough to enter lungs and cause damage. It is carcinogenic. It creates smog, a stealthy killer.
- Indian diesel has high sulphur content (0.05%) as compared to the fuel used in
- Europe where the sulphur is as low as (0.03%) in countries like Sweden.
- Fuel quality has to be improved and this means massive investment in refinery up gradation.

II. METHODOLOGY

Basically, an aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube may have holes of different diameters. The very purpose of providing different diameter hole is to break up gas mass to form smaller gas bubbles. Generally, 3 sets of holes are drilled on the perforated tube. The other end of the perforated tube is closed by plug. Around the circumference of the perforated tube a layer of activated charcoal is provided and further a metallic mesh covers it. The whole unit is then placed in a water container. A small opening is provided at the top of the container to remove the exhaust gases and a drain plug is provided at the bottom of the container for periodically cleaning of the container. At the inlet of the exhaust pipe a non-return valve is provided which prevents the back flow of gases and water as well. The design of aqua silencer requires following components.

A. CONTAINER

The container is rectangular structural unit with opened top shown in figure 1. Process used in making this unit is arc welding. The purpose of using galvanized cast iron as container is because to prevent the possibilities of getting rust.

Galvanization (or galvanization) is the process of applying a protective metallic coating to an underlying piece of metal, in order to prevent rusting. In current use, the term refers to the coating of steel or iron with zinc. This is done to prevent galvanic corrosion (specifically rusting) of the ferrous item. The value of galvanizing stems from the relative corrosion resistance of zinc, which, under most service conditions, is considerably less than those of iron and steel.

This container is used to hold the water with submerged perforated tube and a charcoal layer around the circumference of the perforated tube.



Fig 1: Container



Fig 2: Perforated tube



Fig 3: Reducer

B. PERFORATED TUBE

The perforated tube made of GI material have holes of different diameters shown in figure 2. The very purpose of providing different diameter hole is to break up gas mass to form smaller gas bubbles the perforated tube of different diameter is generally contains 3 sets of holes are drilled on the perforated tube. The other end of the perforated tube is closed by plug. The choose of this material is to prevent perforated tube from getting rust as it is submerged in water.

C. REDUCER

A fitting that connects two different size pipes is a reducer made up of GI material shown in figure 3. In a reducing coupling, both sides are designed to receive two different size pipe ends to achieve same result as a coupling. Here it is used to connect the larger diameter perforated tube to the exhaust pipe of the engine.

III. DESIGN AND ITS RELATIVE CALCULATIONS

A. CONTAINER

Since, the perforated tube is placed at $5/12^{\text{th}}$ of the container from the base. So, the hydrostatic pressure which comes into picture because of the head of water above the perforated tube is one of the prime factors for the design of the container. It is necessary that there must be sufficient amount of water in the container in order to properly dissolve the exhaust gases and also it is necessary to reduce the hydrostatic pressure. Hence, the base is considered more than the width which satisfies the above conditions shown in fig 4.

Tank dimensions Length, L=60cm Width, B=50cm Height, H=60cm

Total volume of the tank=LBH=1,80,000 cm³

B. PERFORATED TUBE

GI pipes (IS No: 1239; Part 1-1990) are made from hot rolled coils of specified thickness shown in figure 5. The pipes are fully galvanized. GI pipes are available in three grades depending on the thickness of the sheet used in the pipe. The three grades are as follows.

1. Light – Class A
2. Medium- Class B
3. Heavy- Class C

Table 7: Classes of pipes

No.	Class of Pipe	Thickness of sheet (m)	Weight per meter (kg)
1	Class A	0.002	1.00
2	Class B	0.00265	1.28
3	Class C	0.00325	1.50

From the above availability it is clearly seen that class A type of G.I. pipes are of lighter weight than that of the other classes of G.I. Pipe. So, in our design we have considered Class A type of G.I. Pipe. The very purpose of providing different diameter hole is to break up gas mass to form smaller gas bubbles. Three sets of holes are drilled on the perforated tube of 8mm, 11mm, 15mm respectively.

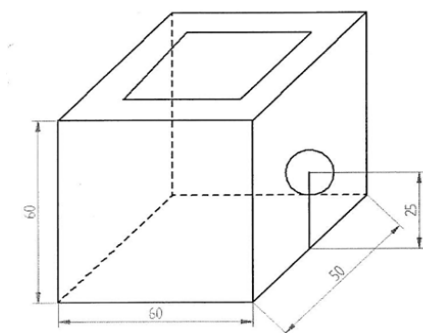


Fig 4: Dimensions of container

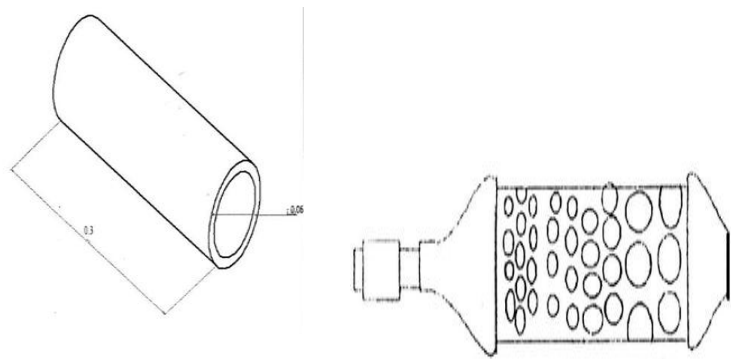


Fig 5: Dimensions of perforated tube

C. REDUCER

A reducer of the dimensions is used to connect the perforated tube of 0.0635m and an exhaust pipe of 0.03175m shown in figure 6.

D. PARAMETERS INVOLVED:

r = exhaust gas density in (kg/m³)

m = mass flow rate (m³/hr)

D_p = back pressure on exhaust pipe (KPa)

D_i = internal diameter (mm)

Exhaust gas density:

$$r = 343 / (273+T) = 343 / (273+250) = 0.66 \text{ kg/m}^3$$

Mass flow rate:

$$m = r A V = 0.66 \times 1.67 \times 10^{-3} \times 5 \times 60 = 0.4952 \text{ kg/sec}$$

Back pressure on exhaust pipe:

$$D_p = 2.44 \times 10^{11} \times m^2 / (D_i^{5.314} \times r) = 2.44 \times 10^{11} \times 0.4952^2 / (45^{5.314} \times 0.66) = 146.60 \text{ mmwc or } 1.43 \text{ KPa}$$

IV. WORKING PRINCIPLE

As the exhaust gases enter in to the aqua silencer, the perforated tube converts high mass bubbles in low mass bubbles after that they pass through charcoal layer which again purify the gases. It is highly porous and possess extra free valences so it has high absorption capacity. After passing over the charcoal layer some of the gases may dissolve in to the water and finally the exhaust gases escape through the opening in to the atmosphere. Hence aqua silencer reduces noise and pollution.

ACTIVATED CHARCOAL

Activated charcoal, also called activated carbon or activated coal is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions as shown in fig 7 & 8.



Figure 6: Dimensions of Reducer



Fig 7: Activated Charcoal

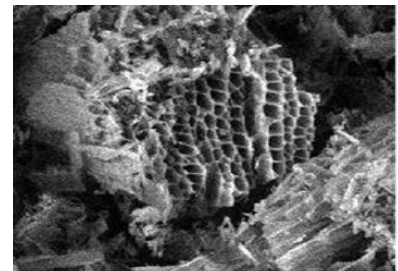


Fig 8: Magnified view of activated charcoal

A gram of activated carbon can have a surface area in excess of 500 m², with 1500 m² being readily achievable. Under an electron microscope, the high surface-area structures of activated carbon are revealed. Individual particles are intensely convoluted and display various kinds of porosity; there may be many areas where flat surfaces of graphite-like material run parallel to each other, separated by only a few nanometers or so. These micro pores provide super conditions for adsorption to occur, since adsorbing material can interact with many surfaces simultaneously. Physically, activated carbon binds materials by Vander Waals force or London dispersion force

V. RESULTS

EXPERIMENTAL DATA

Type of Engine: 2 Stroke (Bajaj Chetak)

Table 8: Results for 2 Stroke Engine

Exhaust Parameter measured (unit)	Prescribed standard	Without aqua silencer	With aqua silencer	Difference %
CO (carbon monoxide) (% vol)	4.5	0.043	0.031	28%
HC(hydrocarbon) (ppm)	9000	672	421	37%

Type of Engine: 4 Stroke (Hero Splendor)

Table 9: Results for 4 Stroke Engine

Exhaust Parameter measured (unit)	Prescribed standard	Without aqua silencer	With aqua silencer	Difference %
CO (carbon monoxide) (% vol)	3.5	0.009	0.007	23%
HC(hydrocarbon) (ppm)	4500	173	92	47%

VI. RESULTS ANALYSIS

- From the above result data sheet, it is clear that the amount of emission level coming out of the engine with aqua silencer is comparatively less than that of the emission coming out of the engine with conventional type of silencer.
- We can also state that the use of water and charcoal whose availability is more and cheap than the catalytic convertor which performs prime function in conventional aqua silencer.
- For 2-stroke engines, emission of hydrocarbon reduces by approx. 37%.
- For 4-stroke engines, emission of hydrocarbon reduces by approx. 47%.
- The amount of NOx produced depends on the temperature since water is used the amount of NOx produced gets reduced.
- Test result reveals that the back pressure developed is negligible

VII. CONCLUSION

- Emission gases from engine exhaust is effectively reduced using aqua silencer.
- Constant back pressure and reduced sound level is obtained using perforated tube.
- Fuel consumption of the engine is found to be unaffected.
- Sound produced at the engine exhaust is lowered due the use of water medium.
- Exhaust emissions are reduced to greater extent due to the use of charcoal.
- Aqua silencer leads to negligible water contamination.
- It is very cheap and provides pollution free and smokeless exhaust.
- It can be used for stationary internal combustion engines but with adoption of more suitable and compact design it can be used in 4 wheel and 2-wheel vehicles

REFERENCES

- [1] Akhil Chowdary Bellam, Meka Raghunadh, Akhil Chirra And S. Ravi Krishna Moorthy, *Fabrication and Testing of Aqua Silencer*, sadgurupublications, ISSN 0972-768X, Int. J. Chem. Sci.: 14(S2), 687-693, 2016.
- [2] Alen, M. Akshay, R. Prem Sankar and M. Mohammed Shafeeque, *Fabrication and Testing of Aqua Silencer*, Int. Res. J. Engg. Technol. (IRJET) e-ISSN: 2395-0056, August 2015.
- [3] Shweta B. Said, Sonali P. Wagh, Prachi D. Gaikwad, Swapnil Kondo, *Aqua Silencer*, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056, Volume: 03 Issue: 03, Mar -2017
- [4] Akhil Anil Kumar, Anoop N, Aquib Jawed P.P, Bijoy E1, Midhun T.V, Mohammed Shiyas.N.P, Ranjith Krishna P.T, *Design and Development of Aqua Silencer*, International Journal of Engineering and Innovative Technology (IJEIT), Volume 5, Issue 11, May 2016