

"ANALYSIS OF AQUA SILENCER"

A Project submitted

to

**CHHATTISGARH SWAMI VIVEKANAND TECHNICAL
UNIVERSITY
BHILAI (C.G.), INDIA**



*In partial fulfillment
For the award of the Degree
of
Bachelor of Engineering
in
Mechanical Engineering
by
Akash Dewangan
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**Under the Guidance of
Mr. Hrishabh Singh Bais
Assistant Professor
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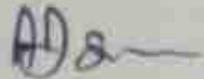
Kohka, Bhilai (C.G.)

Session: 2017-2018

DECLARATION BY THE CANDIDATE

I the undersigned solemnly declare that the report of the project work entitled "**ANALYSIS OF AQUA SILENCER**", is based on my own work carried out during the course of my study under the supervision of Mr. Hrishabh Singh Bais.

I assert that the statements made and conclusions drawn are an outcome of the project work. I further declare that to the best of our knowledge and belief that the report does not contain any part of any work which has been submitted for the award of any other degree/diploma/certificate in this University or any other University. All helps received and citations used for the preparation of the project have been duly acknowledged.



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CERTIFICATE OF THE SUPERVISOR

This is to certify that the report of the project entitled "**ANALYSIS OF AQUA SILENCER**", is a record of bonafide project work carried out by **Akash Dewangan** (Roll No.: 3423714005, Enrollment No.: AP7537) under my guidance and supervision for the award of Degree in Bachelor of Engineering in Mechanical Engineering of Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.), India. To the best of my knowledge and belief the report.

- Embodies the work of the candidate himself,
- Has duly been completed,
- Fulfils the requirement of the Ordinance relating to the B.E. degree of the University and
- Is up to the desired standard both in respect of contents and language for being referred to the examiners.



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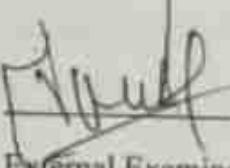
CERTIFICATE BY THE EXAMINERS

This is to certify that the project work entitled "ANALYSIS OF AQUA SILENCER" Submitted by Akash Dewangan (Roll No.: 3423714005, Enrollment No.: AP7537) has been examined by the undersigned as a part of the examination and is hereby recommended for the award of Bachelor of Engineering degree in the faculty of Mr. Hrishabh Singh Bais Mechanical Engineering of Chhattisgarh Swami Vivekanand Technical University, Bhilai.



Internal Examiner

Date: 17/05/2018



External Examiner

Date: 17/05/2018

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ABSTRACT

Air pollution is most important from the public health of view, because every individual person breaths approximately 22000 time a day, inhaling about 15 to 22 kg of air daily. Polluted air causes physical ill effect decides undesirable aesthetic and physiological effects. Air pollution can be defined as addition to our atmosphere of any material, which will have a dexterous effect on life upon our planet. The main pollutants contribute by automobile are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOx) and Lead. Automobiles are not the only sources of air pollution, other sources such as electric power generating stations, industrial and domestic fuel consumption, refuse burning, industrial processing etc. also contribute heavily to contamination of our environment so it is imperative that serious attempts should be made to conserve of our environment from degradation. An Aqua Silencer is an attempt, in this direction; it is mainly dealing with control of emission. An Aqua Silencer is fitted to the exhaust pipe of engine. Sound produced under water is less hearable than it produced in atmosphere. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. Because of this property water is used in this silencer and hence its name AQUA SILENCER. The noise and smoke level is considerable less than the conventional silencer, it is cheaper, no need of catalytic converter and easy to install. 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.

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LIST OF ABBREVIATIONS AND SYMBOLS

CO = Carbon monoxide

UBHC = Unburned Hydrocarbons

NOX = Oxide of Nitrogen

Pb = Lead

CO₂ = Carbon dioxide

SO₂ = Sulfur dioxide

RPM = Revolution per minute

m = Meter

$\sqrt{^{\circ}R}$ = Absolute Temperature of the Exhaust Gas

ASHRAE = American Society of Heating, Refrigerating and Air – Conditioning Engineers

NO₂ = Nitrogen dioxide

H₂O = Water

HNO₂ = Nitrous Acid

HNO₃ = Nitric Acid

Ca(OH)₂ = Calcium Hydroxide

Ca(NO₂)₂ = Calcium Nitrite

Ca(NO₃)₂ = Calcium Nitrate

CaCO₃ = Calcium Carbonate

Ca(HCO₃) = Calcium bicarbonate

CaSO_3 = Calcium Sulfite

SO_3 = Sulfur trioxide

SO_4 = Sulfate

H_2SO_4 = Sulfuric Acid

H_2SO_3 = Sulfurous Acid

HC = Hydrocarbon

PVC = Poly Vinyl Chloride

PPM = Parts Per Million

KJ = Kilo Joule

Hz = Hertz (Unit of Frequency)

Pa = Pascal (Unit of Pressure)

Mm = Millimeter (Unit of Length)

Hp = Horse power (Unit of Power)

Nm = Newton meter (Unit of Torque)

Kg = Kilogram (Unit of Mass)

KN = Kilo Newton (Unit of Force)

K = Kelvin (Unit of Temperature)

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1.1 INTRODUCTION

An aqua silencer System is designed to replace conventional single unit engine silencers on board structures. With its light weight and slender design, it offers a minimal 'footprint' while optimizing the entire exhaust system for low noise and reduced backpressure. It is used to control the noise and emission in IC engines. The reason why we go for aqua silencer is, in today life the air pollution causes physical ill effects to the human beings and also the environment. The main contribution of the air pollution is auto mobile releasing the gases like carbon dioxide and unburned Hydrocarbon. In order to avoid this type of gases by introducing this aqua silencer. It is fitted to the exhaust pipe of the engine; Sound produced under water is less hearable than it produced in atmosphere. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. The emission can be controlled by using the activated charcoal layer and it is highly porous and posses extra free valences so it has high absorption capacity. So absorb the gases from the engine and release much less position to the environment. The noise and smoke level is considerable less than the conventional silencer, no need of catalytic converter and easy to install. In this silencer, the Charcoal and Water so it is called hybrid aqua silencer, and it is useful in automobile, industry, DG sets & DG machines, Marin and Boats also, It is known as hybrid universal aqua silencer.

Now a day's Air pollution is major problem, the main pollutants contribute by automobiles are (CO), UBHC, (Nox) and Lead etc. Other sources such as electric power generating stations, industrial and domestic fuel consumption refuse burning, industrial processing. 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 engine.

1.2 AQUA SILENCER

- Basically an Aqua Silencer consists of a perforated tube which is installed at the end of the exhaust pipe.
- The perforated tube of providing different diameter hole is to break up gas mass to form smaller gas bubbles.
- Generally 4 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 at the top of the container to remove the exhaust gases & a drain plug is provided at the bottom of the container for periodically cleaning of container.

Also a filler plug is mounted at the top 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.

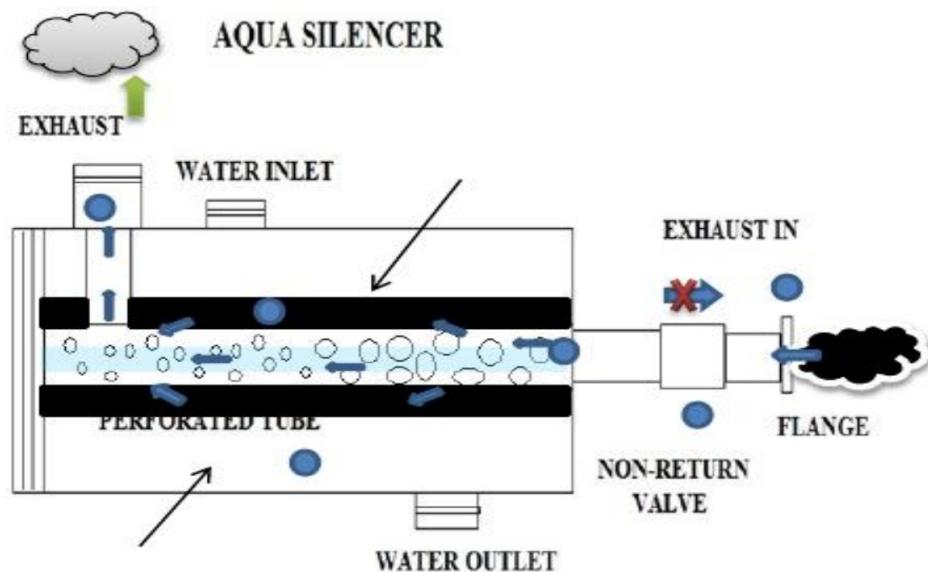


Fig- 1.1 Basic Design of Aqua Silencer

2.1 LITERATURE REVIEW

The exhaust gas contains carbon-di-oxide, sulphur-di-oxide, carbon monoxide and other oxides of nitrogen. At full load, the temperature of the exhaust gas will lay anywhere between 500°C to 700°C.

The pressure of the exhaust gas depends upon so many factors viz.

- The design of exhaust gas manifold
- Magnitude of valve overlaps
- Engine speed
- Number of cylinders
- The length of the exhaust gas flow path etc.

The design of exhaust gas manifold is very important in case of high speed diesel engines. In order to maintain the exhaust gas pressure within the required limits, the exhaust gas manifold is designed, so that, the gases which come out of the cylinder flows very smoothly, before it is let out to the atmosphere.

This is absolutely essential in order to maintain the back pressure within safe limits, so that the engine can be kept at the optimum operating level. The back pressure. If it is allowed to exceed the predetermined level, the effort on the part of the piston for scavenging is considerably increased and so power is lost in performing the above, so the primary consideration when introducing any modification in exhaust system does not increase the back pressure which drastically affect the performance characteristics of the engine. To be more precise, the speed of the engine is affected for given specific fuel consumption rate and so the consumption characteristics of an engine are affected. As a net result of the combustion is not proper and complete which results in the increased impurities or unburnt gases.

This principle against the purpose of introducing any system whose sole object is reducing the very toxic property of the exhaust gas. So, it is implied that the introduction of any system reduces the toxic property of the exhaust gas, shall not result in any effects in the opposite direction.

So by introducing any component in the system the flow path length and the resistance to flow are indirectly increased. So the increase of pressure is inevitable unless the increase in magnitude compensated in the design of the component itself.

The exhaust gas has to pass through the water, which is filled in the scrubber tank. In any case, the outlet from the engine shall be kept below the water level in the scrubber tank for that the gas will pass through the water. The gas has no to push the water, in order to bubble through the water. The gas has to push the water, in order to bubble through the water in the scrubber tank. This may create chances to increase the backpressure. The baffles, which are provided to deflect the exhaust gases, also offer resistance to the flow and in turn increase the back pressure. Due to the high temperature, the exhaust gas is let out from the engine, some of the water particles which come in contact, readily changes its phase from liquid state to gaseous state i.e., Steam which increases the net mass of the exhaust gas flow per unit time. The resultant may increase the backpressure.

The lime stone container is used to store the lime stone and offers a definite and increased resistance to flow, which again contributes to increase of back pressure. The lime stones are originally intended to reduce the toxic ingredients of the exhaust gas through chemical reaction. It is evidently affected the flow of resistance and hence the combustion characteristics of the engine will finally contribute the increased toxic ingredients of the exhaust gas. Because of the introduction of the scrubber. The net length of exhaust gas flow path is also increased which is again against the original intention.

So, all the above factors contribute for the increased back pressure of the system, the system has to be so designed or constructed to reduce the above increase of pressure to its original intended value or original designed value of the engine exhaust system. This could be in principle, accomplished by so many ways. Basically, the elimination of a separate silencer will have way solve the problem, because the scrubber tank, it will act as a silencer and hence the resistance offered by a separate silencer, which is eliminated totally. The introduction of the bellmouth assembly facilitates the exhaust gas to expand many times by volume gradually before it is coming in contact with the water in the scrubber tank.

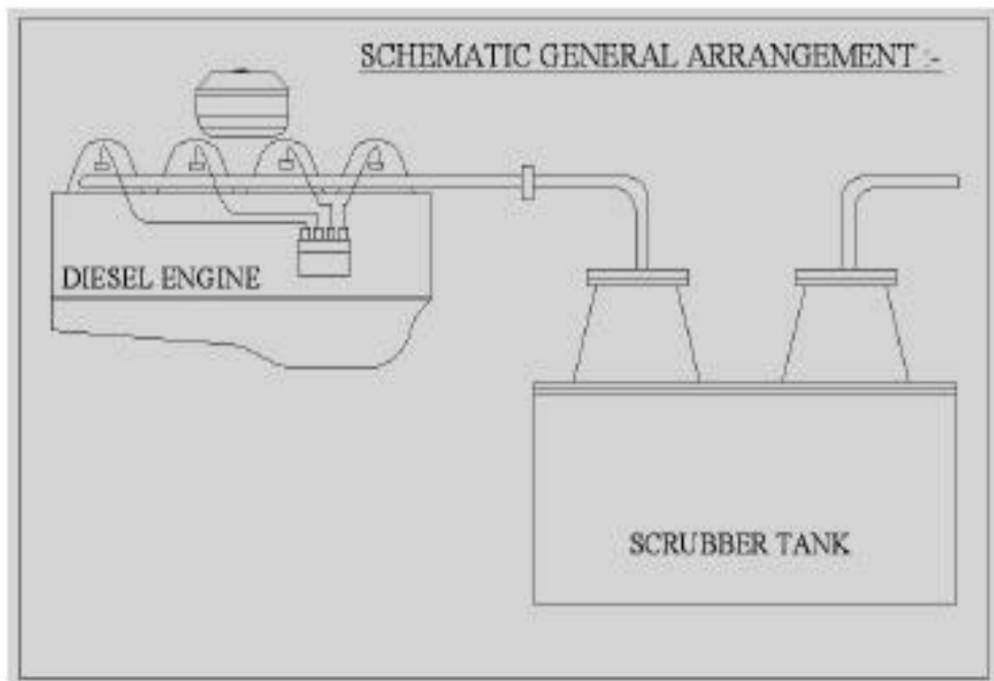


Fig- 2.1 Arrangement of Scrubber Tank

3.1 DESIGNING AND CALCULATION OF MUFFLER

A muffler have been designed which is of super critical grade type and includes all the three attenuation principles i.e., reactive, followed by absorptive type muffler, and a side branch resonator. The interesting events of the design are continuous volume reduction of chambers in the reactive part, the flow pipe cross-sectional area is maintained constant throughout, a layer of insulation outside the reactive part, the placing of side branch resonator compactly, option for tuning the resonator using a screw and cylinder.

- **Design Data**

For the experiment, an existing petrol engine has been used. Calculations are done on the basis of data collected from the engine however, some data are applicable to all engines. For designing, the following data are required

SOUND CHARACTERISTICS (WITHOUT SILENCER)

- Rpm of the engine = 2026

3.1.1 SOUND ANALYSIS WITH FREQUENCY ANALYZER (TO OBTAIN THE DOMINATING FREQUENCY)

Two dominating frequencies, the low level and the high level have been obtained. These are

Table 3.1 Sound Analysis with Frequency Analyzer

Frequency Level	Frequency (Hz)
Low	270
High	40000

3.1.2 DIAMETER OF EXHAUST PIPE OF ENGINE/INLET PIPE OF MUFFLER

- The Exhaust Pipe diameter: 1.5 inch

3.1.3 THE THEORETICAL EXHAUST NOISE FREQUENCY RANGE

- From various experiments it has been found that the theoretical exhaust noise frequency is 200-500Hz

3.2 REFLECTIVE PART DESIGN

Exhaust pipe diameter = 1.5 inch

The dimensions to determine are that of the chamber length L and the body diameter.

To determine L, three methods have been used. They are as follows:

First method used to determine L

Maximum attenuation occurs when

$$L = n\lambda/4 \dots \dots \dots \quad (1.1)$$

where, λ = wavelength of sound (m or ft)

$n = 1, 3, 5, \dots \dots$ (odd integers)

Since λ is related to frequency by the speed of sound, one can say that the peak attenuation occurs at frequencies which correspond to a chamber length.

The range of frequency is obtained from the design data in section. The following table of L has been constructed with this data.

3.3 CALCULATED WAVELENGTH FROM FREQUENCIES

Table 3.2 Calculated Wavelength

Frequency	$\lambda = C/f$ (m)	Λ (inch)	$n = \text{odd}$ integer	L (inch) $L = n\lambda/4$
N(min) 200 Hz	1.65 (λ_{\max})	67.2 (λ_{\max})	1 3	16.4 50.4
N(max) 500 Hz	0.66 (λ_{\min})	26.9 (λ_{\min})	1 3	6.72 20.16

Table 3.3 Sound Level

	SOUND LEVEL
Without any load	104.5 dbA
50% load	106.5dbA
100% load	107dbA

From Table, we can find that L has a range between 6.72 and 50.4 inch. Due to space limitation, the length of the small chamber has been chosen to be 6.72 inch and 20.16 or 20 inch for the whole of the chambers.

- **Range of chamber length considering the temperature of exhaust gas**

Another factor which must be considered in expansion chamber design is the effect of high temperature of exhaust gases. This factor can easily be included in the design by using the following equation:

$$0.5 (49.03\sqrt{^{\circ}R}) / 2\pi f \leq L \leq 2.6 (49.03\sqrt{^{\circ}R}) / 2\pi f \dots \dots \dots \quad (1.2)$$

where, $\sqrt{^{\circ}R}$ =absolute temperature of the exhaust gas

f = frequency of sound (Hz)

Let the temperature of exhaust is assumed to be 759.7° R

Putting this value in equation (1.2),

We obtains,

$$0.5 (49.03\sqrt{759.7}) / 2\pi 270 \leq L \leq 2.6 (49.03\sqrt{759.7}) / 2\pi 270$$

(here, $f = 270$ Hz for low frequency reactive muffler)

$$0.4 \text{ ft} \leq L \leq 2.04 \text{ ft}$$

From the 1st method, $L = 20$ inch = 1.67 ft.

So the condition of $0.4 \text{ ft} \leq 1.67 \leq 2.04 \text{ ft}$ is satisfied.

- **Range of chamber length according to ASHRAE Technical Committee**

According to ASHRAE Technical Committee 2.6, muffler grades and their dimensions, the requirement matches with the super critical grade.

$IL = 35$ to 45 dBA

Body/Pipe = 3

Length/Pipe = 10 to 16

That is, $10 \times \text{pipe dia} \leq L \leq 16 \times \text{pipe dia}$

$$10 \times 1.5'' \leq L \leq 16 \times 1.5''$$

$$15'' \leq L \leq 24''$$

Again the chosen length $L = 20$ inch, satisfies the above condition

- Tail Pipe Design

According to equation (1), resonance occurs when $L = n\lambda/2$. So, for an economical construction, the value of n may be taken as 1. Then the tail pipe must be less than $\lambda/2$. So from the table we can find the tail pipe length 3.36 inch or less than it.

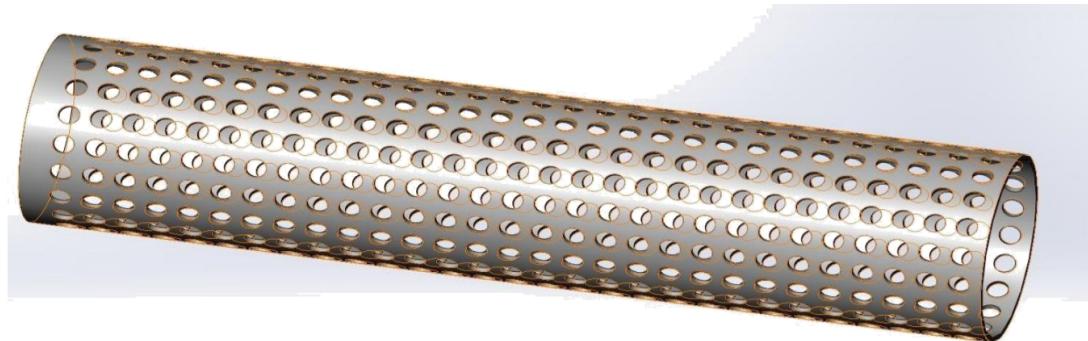


Fig- 3.1 Identical Perforated Tube



Fig- 3.2 Aqua Silencer

4.1 CONSTRUCTION OF AQUA SILENCER

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 the perforated tube of different diameter .Generally 4 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. Also a filler plug is mounted at the top 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.

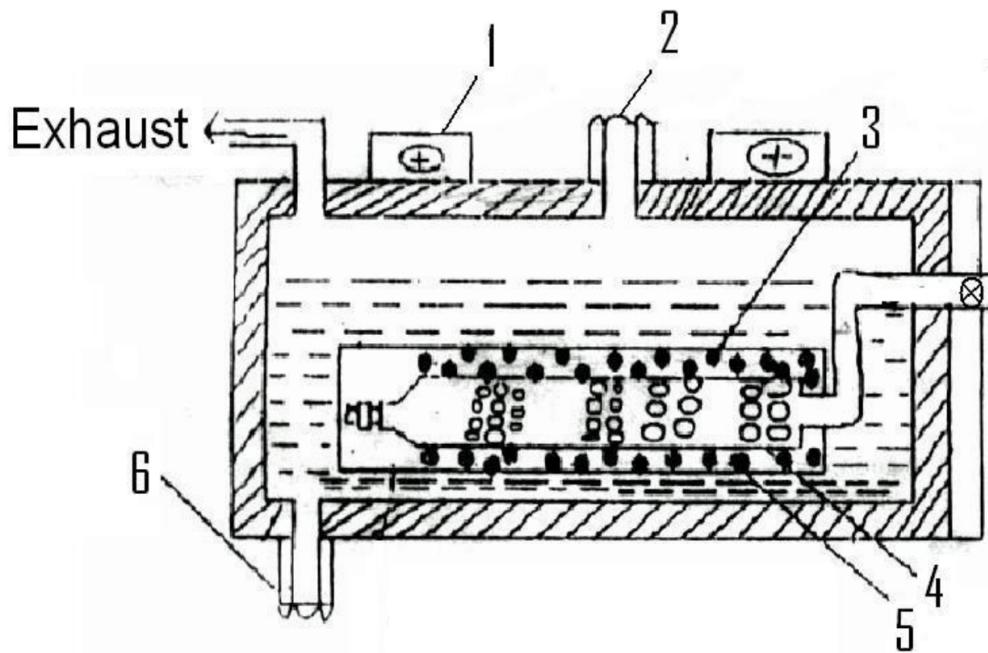


Fig. 4.1 Basic Arrangement of Aqua Silencer

4.2 COMPONENTS AND EXPLANATION

Components:

- Perforated Tube
- Non-return valve
- Outer shell
- Flange
- Charcoal layer
- Mountings
- Filler Plug
- Wire Mesh
- Drain Plug

Explanation:

- **Perforated Tube**

The perforated tube consists of number of holes of different diameters. It is used to convert high mass bubbles to low mass bubbles. The charcoal layer is pasted over the perforated tube.

- **Charcoal Layer**

The charcoal layer has more absorbing capacity because it has more surface area. This charcoal is called as Activated Charcoal. It is produced by heating the charcoal above 1500 °C for several hours in a burner. Its surface area gets increased.

- **Outer Shell**

The whole setup was kept inside the outer shell. It is made up of iron or steel. The water inlet, outlet and exhaust tube was provided in the shell itself.

- **Non-return Valve**

The non-return valve is provided instead of a non return valve which is a mechanical device, which normally allows fluid (liquid or gas) to flow through it in only one direction. The Aqua silencer was filled with water and it is directly connected to the exhaust pipe of the engine. There is a chance for the water to get enter into the engine cylinder. To avoid this non-return valve is used.

- **Flange**

A flange joint is a connection of pipes, where the connecting pieces have flanges by which the parts are bolted together. Here flange is used to connect the silencer to the engine.

4.3 WORKING PRINCIPLE

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

Following chemical reactions takes place in aqua silencer:

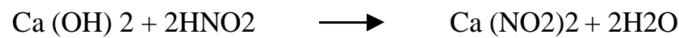
- Chemical Reaction 1**

The obnoxious product of combustion is NO_x – the oxides of Nitrogen. Water will absorb the oxides of Nitrogen to a larger extent. The following chemical reaction will enhance the proof, for the above statement.



- Chemical Reaction 2**

If a small amount of limewater is added to scrubber tank, further reaction takes place as below.



- Chemical Reaction 3**

When the carbon-di-oxide present in the exhaust gas comes in contact with the limewater, calcium carbonate will precipitate. The calcium carbonate when further exposed to carbon-di-oxide, calcium-bi-carbonate will be precipitated. The following chemical reaction is



- **Chemical Reaction 4**

The sulphur-di-oxide present in the Diesel Exhaust also reacts with the lime water. But the small trace of sulphur-di-oxide makes it little difficult to measure the magnitude of the chemical reaction, accurately. The following equation gives the chemical reaction and calcium sulphite will precipitate



From calcium carbonate, calcium sulphite will precipitate and CO₂ will be by-product. Because of the small percentage and SO₂ presence, the liberation of Carbondioxide is very less. But the liberated CO₂ will again combine with CaCO₃ to form calcium bi carbonate.

4.4 EFFECTS ON DISSOLVED GASES ON WATER

The water is a good absorbing medium. In aqua silencer the gases are made to be dissolved in water. When these gases dissolved in water they form acids carbonates, bicarbonates etc.

- Action of dissolved SO_x
- Action of dissolved CO_2
- Effect of dissolved NO_x

- **Action of dissolved SO_x**

When SO_x is mixed in water, it forms SO_2 , SO_3 , SO_4 , H_2SO_4 , i.e. sulfuric acid (H_2SO_4), it forms Hydrogen Sulphide which causes egg smell, acidify and corrosion of metals.

- **Action of dissolved CO_2**

The dissolved carbon dioxide forms bicarbonate at lower PH and Carbonates at higher PH. This levels 40-400 mg/liter. Form a scale in pipes and boilers. The carbon dioxide mixes with water to form Carbonic acid. It is corrosive to metals and causes green house effect

- **Action of dissolved NO_x**

The Nitrogen in water undergoes Oxidation to form ammonia, Nitrate, Nitrite, Nitric acid. This synthesis of protein and amino acids is effected by Nitrogen. Nitrate usually occurs in trace quantities in surface water. A limit of 10 mg per liters Nitrate is affordable

4.5 METHODS TO CONTROL THE WATER POLLUTION

There are two methods

- **Lime water wash method.**
- **Absorption process**

Lime water wash method

- The water is treated with the calculated quantities of slaked lime. After mixing the heavy precipitates settle down as sludge at the bottom of the tank are removed from time to time.
- Lime can neutralize any acid present in the water. SO₂, gases are removed from the flue gases forming calcium sulphate.
- The precipitates dissolved carbon dioxide as calcium carbonate and converts bicarbonate ions into carbonates.

Limitation of lime water wash method

- Amount of neutralization capacity is limited
- It is very difficult to handle
- Bridging and form are formed
- It is expansive
- Regeneration is possible
- Lime in any form it is difficult to handle

Absorption Process

- Activated charcoal is available in granular or powdered form. As it is highly porous and possess free valences. So it posses high absorption capacity.
- Activated carbon is more widely used for the removal of taste and odorous from the public water supplies.
- Because it has excellent properties of attracting gases, finely divided solid particles and phenol type impurities, The activated carbon, usually in the powdered form is added to the water either before or after the coagulation with sedimentation

Advantages of absorption process

- It increases the coagulation power of the process.
- Its use reduces the chlorine demand.
- The excessive dose of activated carbon is not harmful.
- The treatment process is very simple and it requires nearly no skill.
- The efficiency of removing color, odour and taste is quite high.
- It can be easily regenerated.
- It has excellent properties of attracting gases.

4.6 OPERATIONAL AND PHYSICAL PARAMETER

- **Perforated Tube**

Perforated tube diameter is 1.5 inch because engine exhaust manifold dia. is same and 12 inch long as per design data and made from the stainless steel because it has a high melting point 1510o C



Fig. 4.2 Perforated tube

EFFECT OF CHANGE IN POROSITY AND CHANGE IN DIAMETER OF PERFORATION HOLE ON BACKPRESSURE

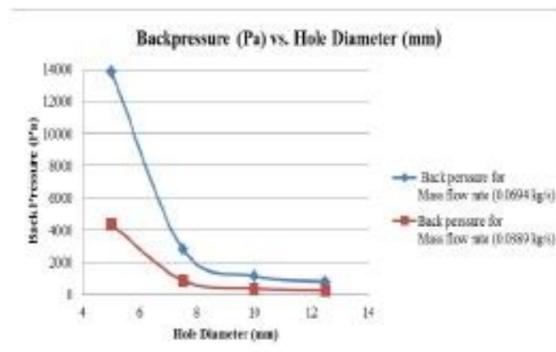


Fig- 4.3 Back Pressure (Pa) Vs Hole Diameter (mm)

Fig. 4.3 Effect Of Change In Porosity From fig- it is observed that for the smallest hole diameter of 5 mm the back Pressure is as high as 13,837 Pa. If we increase the diameter of the hole Back Pressure rapidly falls down and it is lowest i.e. 788 Pa for the hole diameter 12.5 mm. The pressure drop is very large which is 75% of highest backpressure for first two hole diameters viz. 5 mm and 7.5 mm. For other hole diameters the pressure drop is small but significant.

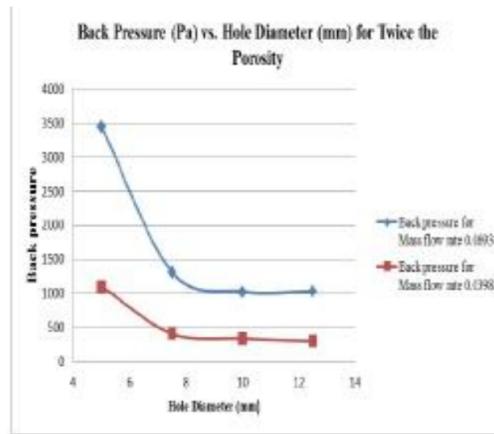


Fig- 4.4 Back Pressure (Pa) Vs Hole Diameter (mm) for Twice the Porosity

Fig- 4.4 Back Pressure Vs Hole Diameter When the porosity is doubled than the conventional, backpressure drops by 75% for first two hole diameters. While for other hole diameters it is fairly the same value with a difference of 20 Pa to 75 Pa. Thus it can be seen that the backpressure value is high for small diameters as compare to bigger diameter holes even if the porosity is doubled. But for higher diameters the Backpressure value remains the same even when the porosity is doubled.

- **Activated Carbon**



Fig- 4.5 Activated carbon pallets

- Size – 0.35 to 0.80 mm
- Shape – Cylindrical pallets

4.7 SPECIFICATION OF ENGINE & WATER

Engine

- Stroke - Two stroke petrol engine.
- Type - Air cooled
- No. of cylinder - Single cylinder
- Bore x Stroke - 42.6 mm x 42 mm
- Displacement - 59.9 cc
- Maximum Power - 3.5 hp at 5500 rpm
- Max. Torque - 4.5 Nm at 5000 rpm

Water

- Thermal properties of water Maximum density - 1000 kg/m³
- Specific weight - 9.807 KN/m³
- Freezing point - 0 °C
- Boiling point - 100 °C
- Latent heat of melting - 334 KJ/Kg
- Latent heat of evaporation - 2270 KJ/Kg
- Specific heat - 4.187 KJ/Kg K
- Thermal expansion - 4 °C to 100 °C

5.1 ANALYSIS REPORT

First we determine the amount of exhaust gas like hydrocarbons, nitrogen etc which is present in the single cylinder petrol engine without connecting Zero emission silencer. And then at Aqua Silencer (with lime water) which is connected to exhaust pipe and readings are taken. The results which are obtained from the project analysis is given below in the tables. Smoke analyzer tests were carried out for analyzing the performance of the silencer.

Table 5.1 PUC Testing of 4 - stroke **Petrol Engine**

	Prescribed Standard CO	Measured level CO	Prescribed Standard HC	Measured level HC
Ordinary Silencer	3.50	0.04	4500	84
Aqua silencer	3.50	0.00	4500	6

CO & HC Level at idling (% volume) (ppm)

Table 5.2 PUC Testing of 4 - stroke **Diesel Engine**

Average Value	Ideal RPM	Max RPM	K_Value	HSU_Value
Ordinary Silencer	870.00	893.00	0.22	8.94
Aqua silencer	820.00	873.00	0.00	0.11

K-Absorbent coefficient and HSU- Hartridge smoke unit

5.2 COMPARATIVE ANALYSIS OF RESULTS

PUC Certificate of Petrol Engine without AQUA SILENCER

प्रदूषण नियंत्रित प्रमाणपत्र POLLUTION UNDER CONTROL CERTIFICATE									
परिवहन विभाग, छत्तीसगढ़ सरकार द्वारा अधिकृत AUTHORISED BY TRANSPORT DEPARTMENT , GOVT. OF CHHATTISGARH									
प्रमाण पत्र संख्या PUCC NO.	p.02.2002-7037	प्रमाणित किया जाता है कि इस वाहन का CO, HC उत्सर्जन स्तर के, नी.गा. अधिनियम 1989 के नियम 115 (2) (ग) में निर्धारित स्तर के अनुसार है। यदि आप को कोई शिकायत है तो कृपया प्रदूषण नियंत्रण प्रक्रिया, परिवहन अधिकृत कार्यालय, को लिखें। In case of any comment/complaint please write to Pollution Control Cell, Transport Commissioner office, C.G.							
वाहन पंजी संख्या Vehicle Reg. No.	CG04 KC 7920	आइडलिंग पर CO स्तर (% आयतन) एवं HC स्तर (%PPM) CO (% vol) & HC (%ppm) level at idling आइडलिंग पर RPM/ Idling RPM 0							
मेक Make	HONDA	निर्धारित मानक CO Prescribed Standard CO	मापित स्तर CO Measured Level CO	निर्धारित मानक HC Prescribed Standard HC	मापित स्तर HC Measured Level HC				
मॉडल Model	SHINE	पेट्रोल Petrol	3.5	0.04	4500 nHexane	84 nHexane			
वर्ग Category	2-Wheelers	सी.एन.जी. / एल.सी.जी. CNG/ LPG							
इंजन स्ट्रोक Engine Stroke	4-STROKE	At high idle RPM 2500+/- 200, Measured RPM.....							
वर्ष Year	2012	CO	HC	CO2	O2	Lambda	NOx		
उत्सर्जन मानक Emission Norms	2&3- Wheelers(4-Stroke),(Vechiles Manufactured after 31st March 2000)								
ईंधन Fuel	PETROL	हस्ताक्षरकर्ता Authorised Signatory							
दिनांक Date	26-Mar-18	नाम Name							
समय Time	1:22:22 PM	अधिकृत केन्द्र कोड Authorised Center Code	p.02.2002						
वैधता Valid upto	25-Sep-18	vijay pollution testing center malviya nagar durg							
  <p>Date of Issue/Valid Time : 26-03-2018 PUCC NO: p.02.2002-7037</p>									

Fig. 5.1 Petrol Engine without Aqua Silencer

PUC Certificate of Petrol Engine with AQUA SILENCER

प्रदूषण नियंत्रित प्रमाणपत्र					
POLLUTION UNDER CONTROL CERTIFICATE					
परिवहन विभाग, छत्तीसगढ़ सरकार द्वारा अधिकृत					
AUTORISED BY TRANSPORT DEPARTMENT , GOVT. OF CHHATTISGARH					
प्रमाण पत्र संख्या PUCC NO.	p.02.2002-7038	प्रमाणित किया जाता है कि इस वाहन का CO, HC उत्सर्जन स्तर के, भी, आयतन अधिनियम 1989 के नियम 115 (2)(ग) में निर्धारित स्तर के अनुसार है। यदि आप को कोई विवादपत्र है तो कृपया प्रदूषण नियंत्रण प्रक्रिया, परिवहन आयुक्त कार्यालय, को लिखें। In case of any comment/complaint please write to Pollution Control Cell, Transport Commissioner office, C.G.			
वाहन पंजी संख्या Vehicle Reg. No.	CG04 KC 7920	आइडलिंग पर CO स्तर (% आयतन) एवं HC स्तर (%PPM) CO (% vol) & HC (%ppm) level at idling आइडलिंग पर RPM/ Idling RPM 0			
मेक Make	HONDA	निर्धारित मानक CO Prescribed Standard CO	मापित स्तर CO Measured Level CO	निर्धारित मानक HC Prescribed Standard HC	मापित स्तर HC Measured Level HC
मॉडल Model	SHINE	ईंचन Fuel	3.5	0	4500 nHexane
वर्ग Category	2-Wheelers	पेट्रोल Petrol			6 nHexane
इंजन स्ट्रोक Engine Stroke	4-STROKE	At high idle RPM 2500+/- 200, Measured RPM.....			
वर्ष Year	26/ 09/ 2018	CO	HC	CO2	O2
उत्सर्जन मानक Emission Norms	2&3- Wheelers(4-Stroke),(Vehicles Manufactured after 31st March 2000)	Lambda		NOx	RPM
ईंचन Fuel	PETROL				Oil Temp
दिनांक Date	26-Mar-18	हस्ताक्षरकर्ता Authorised Signatory			
समय Time	1:27:01 PM	नाम Name			
वैधता Valid upto	25-Sep-18	अधिकृत केन्द्र कोड Authorised Center Code	p.02.2002		
		Vijay pollution testing center malviya nagar durg			
 					
PUC NO. p.02.2002-7038					

Fig. 5.2 Petrol Engine with Aqua Silencer

PUC Certificate of Diesel Engine without **AQUA SILENCER**

COMPUTERISED EMISSION TEST CERTIFICATE Authorise Transport Dept. of Chhattisgarh VIJAY POLLUTION TESTING CENTER DURG																																			
																																			
Liscence Number :- 02/2002 I.D. Number :- 9871 Year Of Registration :- 2012 Vehicle Registration Number :- CG07 CA 3755			Date :- 26/03/2018 Time :- 2:03:59 PM Owner :- JAI SHADARAM TRADERS Driver :- Test Fee :- Fuel :- Diesel Oil Temperature :- 0 Result :- Pass Valid Upto :- 25/09/2018																																
Spedometer:- Engine Numeber :- 98580 Chasis Number :- 12094 Vehicle Color :- White Vehicle Make :- MAHINDRA Vehicle Model :- BOLERO CAMPER Type Of Engine :- 4S Type of Vehicle :- 4W																																			
<table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse; width: fit-content;"> <thead> <tr> <th></th> <th>Ideal RPM</th> <th>Max RPM</th> <th>K_Value</th> <th>HSU_Value</th> <th>Oil Temp</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>870</td> <td>910</td> <td>0.33</td> <td>13.06</td> <td>0</td> </tr> <tr> <td>2</td> <td>870</td> <td>900</td> <td>0.33</td> <td>13.06</td> <td>0</td> </tr> <tr> <td>3</td> <td>870</td> <td>870</td> <td>0.00</td> <td>0.11</td> <td>0</td> </tr> <tr> <td>Avg</td> <td>870.00</td> <td>893.00</td> <td>0.22</td> <td>8.94</td> <td></td> </tr> </tbody> </table>							Ideal RPM	Max RPM	K_Value	HSU_Value	Oil Temp	1	870	910	0.33	13.06	0	2	870	900	0.33	13.06	0	3	870	870	0.00	0.11	0	Avg	870.00	893.00	0.22	8.94	
	Ideal RPM	Max RPM	K_Value	HSU_Value	Oil Temp																														
1	870	910	0.33	13.06	0																														
2	870	900	0.33	13.06	0																														
3	870	870	0.00	0.11	0																														
Avg	870.00	893.00	0.22	8.94																															
Certified that this Vehicle's K-Mean and HSU% value conforms to be Standards prescribed under Rule 115(2) of CMVR Rules 1989, this certificate is valid for 6 Months																																			
 Name of Authorise Signatory with Seal of Testing Center																																			

Fig. 5.3 Diesel Engine without Aqua Silencer

PUC Certificate of Diesel Engine with AQUA SILENCER

COMPUTERISED EMISSION TEST CERTIFICATE																																			
Authorise Transport Dept. of Chhattisgarh																																			
VIJAY POLLUTION TESTING CENTER DURG																																			
																																			
Liscence Number :- 02/2002			Date :- 26/03/2018																																
I.D. Number :- 9872			Time :- 2:07:45 PM																																
Year Of Registration :- 2012			Owner :- JAI SHADARAM TRADERS																																
Vehicle Registration Number :- CG07 CA 3755			Driver :-																																
Spedometer:-			Test Fee :-																																
Engine Numeber :- 98580			Fuel :- Diesel																																
Chasis Number :- 12094			Oil Temperature :- 0																																
Vehicle Color :- White			Result :- : Pass																																
Vehicle Make :- MAHINDRA			Valid Upto :- 25/09/2018																																
Vehicle Model :- BOLERO CAMPER																																			
Type Of Engine :- 4S																																			
Type of Vehicle :- 4W																																			
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	Ideal RPM	Max RPM	K_Value	HSU_Value	Oil Temp																														
1	820	770	0.01	0.22	0																														
2	820	1080	0.00	0.00	0																														
3	820	770	0.00	0.11	0																														
Avg	820.00	873.00	0.00	0.11																															
<p>Certified that this Vehicle's K-Mean and HSU% value conforms to be Standards prescribed under Rule 115(2) of CMVR Rules 1989, this certificate is valid for 6 Months</p> <div style="text-align: right; margin-top: -20px;">  Name of Authorise Signatory with Seal of Testing Center </div>																																			

Fig. 5.4 Diesel Engine with Aqua Silencer

5.3 MERITS AND DEMERITS

Merits

- No vibration when the engine is running.
- Start the engine easy.
- Control emission and noise in greater level.
- Carbon is precipitated.

Demerits

- Lime water filling is required once in a year
- Silencer weight is more comparing to conventional silencer.
- Additional space is required.

CONCLUSION

The aqua silencer is more effective in the reduction of emission gases from the engine exhaust using perforated tube and charcoal. By using water as a medium the sound can be lowered and also by using activated charcoal in water we can control the exhaust emission to a greater level. The water contamination is found to be negligible in aqua silencer. It is smokeless and pollution free emission and also it is very cheap. It can be also used both for two wheelers and four wheelers and also can be used in industries.

FUTURE SCOPE

There has been an increasing concern in recent years over the increasing of transportation and discharge of industrial waste waters into environment. The engine emission contains air pollutants and other species. Almost all pollutants are toxic in nature. Some of the examples are CO, CO₂, NOX, and Hydrocarbon. Among the air pollutants, all are most effective pollutants. Hence, the removal of pollutants was selected for the present study. Several expensive techniques are available in developed countries. But in developing countries like India is not applicable since adsorption technique is less expensive and economically feasible, it has been selected for the present study using some cheap cost chemicals as an effective adsorbent. Therefore the objective of the present work was to test the ability of some chemicals in removing air pollutants from engine emission .In future researches are going on to develop an aqua silencer which can be fitted in to automobiles without effecting its aerodynamics properties and efficiency.

REFERENCES

- “Developments of Emission and Noise Control Device”, International Journal of Modern Trends in Engineering and Research, Vol. 02, Issue 01
- K. Kannan & M. Udayakumar, (October 2009) “NOx and HC Emission Control Using Water Emulsified Diesel in Single Cylinder Diesel Engine”, ARPN Journal of Engineering and Applied Sciences, Vol. 4, No 8
- “Design and Development of Aqua Silencer for Two Stroke Petrol Engine”, International Journal of Innovative Research in Science & Technology Vol. 1, Issue 1, June 2014
- Guromoorthy S. Hebbar & Anantha Krishna Bhat, (July - Aug. 2012) “Diesel Emission Control by Hot EGR and Ethanol Fumigation; an Experimental Investigation”, International Journal of Modern Engineering Research, Vol. 2, Issue 4, pp-1486-1491
- <http://aquapowerltd.com>
- Internal Combustion of Engines- M. L. Mathur, R. P. Shrma
- Engg. Chemistry - Jain & Jain

WEBSITES

- www.efunda.com
- www.nmri.go.jp/eng
- www.mmsonline.com
- www.sciencedirect.com