Design And Development Of Aqua Silencer For Two Stroke Petrol Engine

KEVAL I. PATEL
Student
SVMIT BHARUCH

MR. SWASTIK R. GAJJAR
Assistant Professor
Department of THERMAL SYSTEM DESIGN

Abstract

Air pollution is most important from the public health of view, because every individual person breaths approximately 22000 times a day, inhaling about 15 to 22 kg of air daily. Polluted air causes physical ill effect decides undesirable aestheticand 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 and noise. 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 then the conventional silencer, it is cheaper, no need of catalytic converter and easy to install.

Keywords: Carbon Monoxide (CO), Unburned Hydrocarbon (UBHC), Oxides of Nitrogen (Nox), AQUA SILENCER.

I. INTRODUCTION

An aqua silencer System is designed to replace conventional single unit engine silencers on board structures. With it's light weight and slender design, it offers a minimal 'footprint' while optimizing the entire exhaust system for low noise and reduced backpressure[2]. 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 automobile releasing the gases like carbondioxide and unburt 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[3].

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 so, It is known as hybrid universal aqua silencer.

II. CONSTRUCTIONOF 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[2].

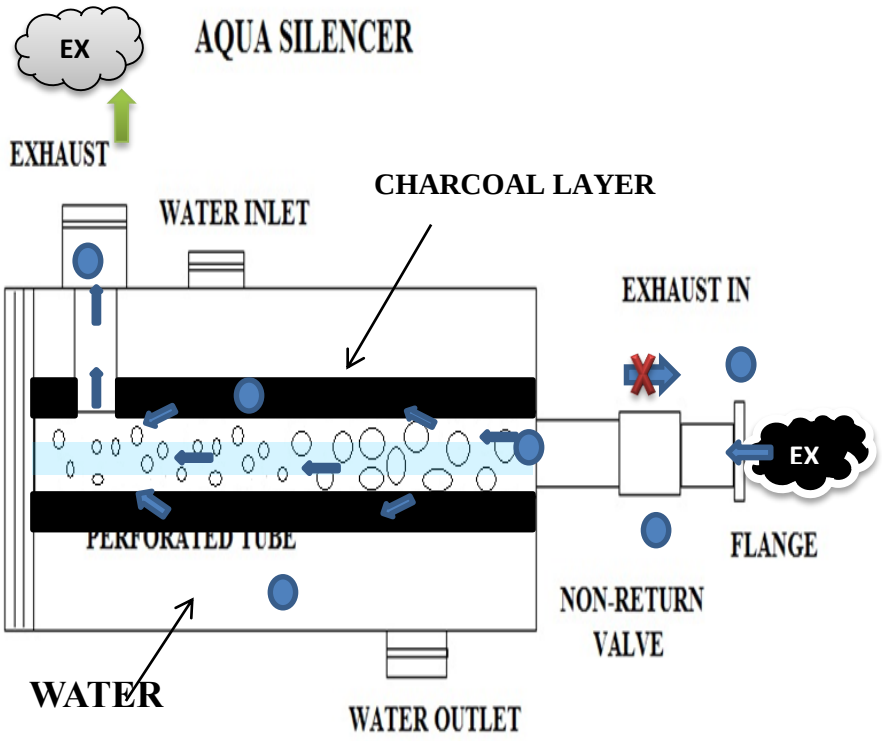

Fig. 1: Working layout

III. WORKING

As the exhaust gases enter in to the aqua silencer, the perforated tube converts high mass bubbles in lo low mass bubbles after that they passes 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.

IV. DESIGNING AND CALCULATION OF MUFFLER

A muffler have been designed which is of supercritical 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.

A. 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.

1) *SOUND CHARACTERISTICS (WITHOUT SILENCER)*

Rpm of the engine= 2026

2) *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:

Frequency Level	Frequency (Hz)
Low	270
High	40000

Table. 1: Two dominating frequencies

3) *DIAMETER OF EXHAUST PIPE OF ENGINE/INLET PIPE OF MUFFLER*

The Exhaust Pipe diameter: 1.5 inch

4) *4.THE THEORETICAL EXHAUST NOISE FREQUENCY RANGE*

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

B. 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:

(1) First method used to determine L

Maximum attenuation occurs when
$L = n\lambda/4$…….(1.1)
where, λ = wavelength of sound (m or ft)
n = 1, 3, 5, …….(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.

C. CALCULATED WAVELENGTH FROM FREQUENCIES

From Table, we can find that L has a range between 6.72

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

Table. 2: Calculated Wavelength

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

Table. 3: Sound Level

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.

(2) 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:
$0.5\ (49.03\sqrt{°R}) / 2\pi f \leq L \leq 2.6\ (49.03\sqrt{°R}) / 2\pi f$……. (1.2)
where, $\sqrt{°R}$=absolute temperature of the exhaust gas
f = frequency of sound (Hz)
Let the temperature of exhaust is assumed to be 759.7º 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 =270Hz 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 $0.4 \text{ ft} \leq 1.67 \leq 2.04$ ft is satisfied.

(3) Range of chamber length according to ASHRAE Technical Committee 2.6

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 × pipe dia ≤ L ≤ 16 × pipe dia

10 × 1.5" ≤ L ≤ 16 × 1.5"

15" ≤ L ≤ 24"

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

D. TAILPIPE DESIGN

According to equation (1), resonance occurs when L= nλ/2. So, for an economical construction, the value of **n** may be taken as 1. Then the tailpipe must be less than λ/2.

So from the table we can find the tail pipe length 3.36 inch or less than it.

E. EXPERIMENTAL ANALYSIS AND RESULT OF AQUA SILENCER

Basically a perforated tube which is installed at the end of the exhaust pipe. The perforated tube consists of number of holes of different diameters 8mm, 4mm, 2mm. It is used to convert high mass bubbles to low mass bubbles. It is made from the stainless steel.

The charcoal layer is pasted over the perforated tube. Bead Activated carbon is used as a charcoal layer. It is a process by which the carbonised product develops porous structure of molecular dimensions and extended surface area on heat treatment in the temperature range of 800 –1000 ^{o}C in presence of suitable oxidising gases such as steam, CO_2. Bead activated carbon is made from petroleum pitch and supplied in diameters from approximately 0.35 to 0.80 mm. It is also noted for its low pressure drop, high mechanical strength and low dust content, but with a smaller grain size. Its spherical shape makes it preferred for fluidized applications.

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. It is made up of iron or steel. The water inlet, outlet and exhaust tube was provided in the shell.[1]

V. OPERATIONAL AND PHYSICAL PARAMETER

A. 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 1510^{o} C

Fig. 2: Perforated tube

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

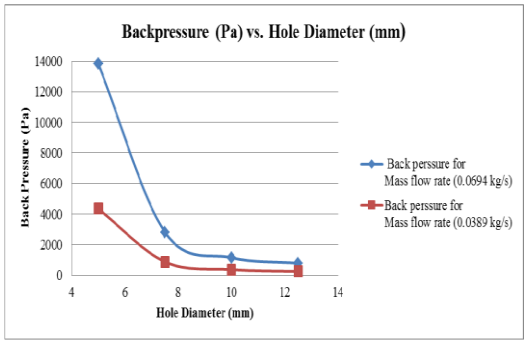

Fig. 3: Effect Of Change In Porosity

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.

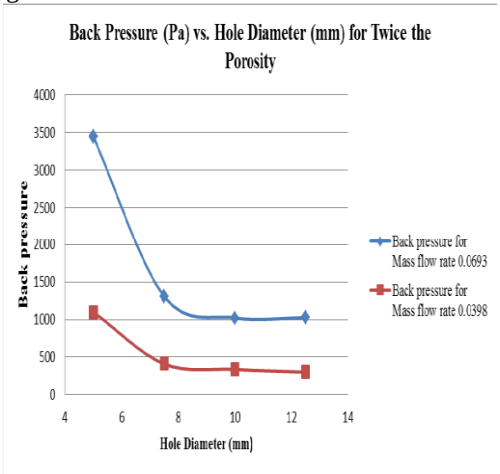

Fig. 3: Back Pressure Vs. Hole Diameter

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.

C. ACTIVATED CARBON

(1) Size – 0.35 to 0.80 mm
(2) Shape – Cylindrical palates

Fig. 4: Activated carbon pallets

D. SPECIFICATION OF 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

E. WATER

Thermal properties of water
Maximum density - 1000 kg/m^3
Specific weight - 9.807 KN/m^3
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/KgK
Thermal expantion - 4 o C to 100 o C

F. EFFECT OF 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.

(1) Action of dissolved SO_2

When SOx is mixed in water, it form SO_2, SO_3, SO_4, H_2SO_4, H_2SO, i.e. sulfur Acid (H_2SO_3,), it forms Hydrogen Sulphide which causes fol rotten egg smell, acidify and corrosion of metals.

(2) Action of dissolved CO_2

The dissolved carbon dioxide forms bicarbonate at lower $_P$H and Carbonates at higher $_P$H. This levels 40-400 mg/liter. The 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.

(3) Effect of dissolved NOx

The Nitrogen in water under goes 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.[6]

G. AQUA SILENCER

Fig. 4: Aqua silencer

An aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube have holes of different diameters. 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.

Fig. 5: Experiment set up

For testing of aqua silencer I used two stroke petrol engine of TVS scooty moped.

Fig. 6: PUC CERTIFICATE

VI. RESULT

From the PUC testing of above two stroke petrol engine I find the following result about Carbon dioxide and hydrocarbon.

	Prescribed Standard CO	Measured level CO	Prescribed Standard HC	Measured level HC
Ordinary Silencer	3.50	0.93	6000	269
Aqua silencer	3.50	0.22	6000	212

Table. 3: CO & HC Level at idling (% volume) (ppm)

A. SOUND CHARACTERISTICS

	SOUND LEVEL WITHOUT SILENCER	**SOUND LEVEL WITH AQUA SILENCER**
Without any load	104.5 db	75 db
50% load	106.5 db	76.5 db
100% load	107 db	78 db

Table. 3: Sound Characteristics

B. ADVANTAGES

- Sound is reduced
- CO is reduced 60 to 70 % compared to ordinary silencer.
- Low cost.

C. DISADVANTAGES

- Aqua silencer is big in size.
- More space is required.

Water refilling and flushing is required periodically.

VII. 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.

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APPENDIX A NOMCLATURE

KFAC - Kenaf fiber activation method
R_{ads} - Adsorption rate
k' - Rate constant
P -Partial pressure

E_a -Activation energy
F -Flux
S -Sticking probability
m -mass of one molecule
T -Temperature in Kelvin
CFR - Cylinder firing rate
λ -Wavelength of sound
C -Velocity of Light
^oR - absolute temp. in renkine
f -Frequency of sound (Hz)

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