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Design, Development and Experimentation of Aqua-Silencer for Four Stroke Petrol Engine

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Abstract - *Aqua Silencer deals with control of emission and noise in automobile exhaust which is achieved by using activated charcoal, perforated tube and outer shell. An aqua silencer is fitted to the exhaust pipe of engine. The main pollutants contributed by automobiles include CO, UBHC, NO_x and Lead etc. The activated charcoal layer filters this harmful nitrous and sulphur content produced from the engine. Sound produced under water is less audible than it produced in atmosphere. This is mostly because of small sprockets in water molecules, which lowers its amplitude thus, sound level decreases. Due to this water is required in this silencer and hence its name AQUA SILENCER. Serious attempts should be made to reduce this pollutants and save our environment*.

Key Words*: *Aqua Silencer, Carbon Monoxide (CO), Oxides of Nitrogen (No_x), Unburnt Hydrocarbon (UBHC).

1. INTRODUCTION

Automobiles are a major source of noise pollution after industries. Air pollution is most important from the public health of view. Polluted air causes physical undesirable aesthetic and physiological effects. Air pollution can be defined as addition of any material to our atmosphere, which will have a dexterous effect on life upon our planet. The main pollutants contributed by engine exhaust are carbon monoxide (CO), unburnt hydrocarbon (UBHC), oxides of nitrogen (NO_x) and Lead. Automobiles are not the only cause of air pollution, other sources such as electric power generating stations, industrial and domestic fuel consumption, industrial processing etc also contribute heavily to contamination of our environment, so it is mandatory that serious efforts should be made to conserve of our environment from degradation. Engines are used for various purposes in power plants, automobiles, locomotives and in various manufacturing. Noise created by these engines becomes a vital concern in residential areas or areas where noise creates various hazard. Generally noise level of more than 80 dB is hazardous for human being. The main sources of noise in an engine are the exhaust and that produced due to friction of various parts of the engine.

2. COMPONENTS

2.1 Perforated tube.

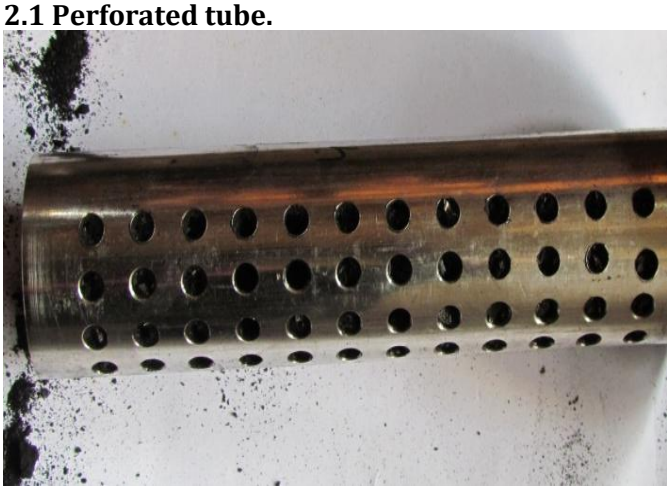

Fig 1:- Perforated tube.

The tube consists of number of holes of different diameters. It is used to transform high mass bubbles to low mass bubbles.

2.2 Charcoal Layer.

Fig 2:- Activated charcoal pallets.

The charcoal layer is fixed over the perforated tube, these charcoal layer has more absorbing capability because it has more surface area. It is called as ACTIVATED CHARCOAL and it is produced by heating the charcoal

above 1500°c for several hours in a burner due to which its surface area gets increased.

2.3 Outer Layer.

Fig 3:– Outer Layer.

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

2.4 Flange

Fig 4: - Flange.

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

2.5 Non Return Valve

Fig 5: - Non Return Valve.

A non return valve which is a mechanical device , which normally allows fluid (liquid or gas) to pass through it in only one direction. It operates on a spring action. The Aqua silencer is filled with water and it is immediately connected to the exhaust pipe of the engine so there is a chance for the water to get enter into the engine cylinder. To avoid this, a non-return valve is used.

3. CONSTRUCTION

An aqua silencer consists of a perforated tube, activated charcoal layer and water which is installed in the exhaust pipe. The perforated tube consist holes of different diameters. The purpose of providing different diameter holes is to break up gas mass to smaller gas bubbles. Generally 4 sets of holes are drilled on the perforated tube. The other end of the tube is closed by plug. Around the circumference of the perforated tube a layer of activated charcoal is provided covered with metallic mesh over it. The entire unit is then placed in a water container. A small opening is provided at the top of the container to discard the exhaust gases and a drain plug is provided at the bottom of the container for repeatedly 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 arranged which prevents the back flow of gases and water as well.

4. WORKING

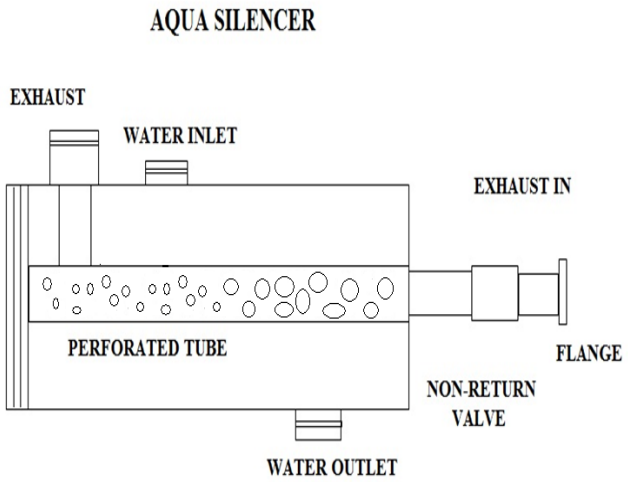

Fig:6 - Aqua-Silencer.

The exhaust gases enter in to the aqua silencer and are received into the perforated tube which converts high mass bubbles into low mass bubbles after which they passes through the charcoal layer which exonerate the gases. This layer is highly porous and posses extra free valences so it has high absorption capacity.

After passing through the charcoal layer some of the gases may dissolved into the water and finally the Exhaust gases liberate through the opening in to the atmosphere. Hence aqua silencer reduces noise and pollution.

5. DESIGN CALCULATION

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

5.1 Design Data

For the experiment, an existing petrol engine has been used. Calculations are done on the basis of data gathered from the engine; however, some data are applicable to all engines. For designing, the following data are important.
1) SOUND CHARACTERISTICS (WITHOUT SILENCER)
Rpm of the engine= 2026
2) SOUND ANALYSIS WITH FREQUENCY ANALYZER (TO OBTAIN THE DOMINATING FREQUENCY)
Two leading frequencies, the low level and the high level have been obtained. These are:

Frequency Level	Frequency (Hz)
Low	270
High	40000

Table. 1: Two leading frequencies

3) DIAMETER OF EXHAUST PIPE OF ENGINE
The Exhaust Pipe diameter: 1.5 inch
4) THE THEORETICAL VALUE OF EXHAUST NOISE FREQUENCY RANGE
From different experiments is has been found that the theoretical exhaust noise frequency is 200-500Hz

5.2 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:
(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.

5.3 Calculated Wavelength From Frequencies

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.

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

Table. 2: Calculated Wavelength

(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:
$0.5\ (49.03\sqrt{°R})\ /\ 2\pi f \le L \le 2.6\ (49.03\sqrt{°R})\ /\ 2\pi f$…….. (1.2)
where, √°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,
$0.5\ (49.03\sqrt{759.7})\ /\ 2\pi 270 \le L \le 2.6\ (49.03\sqrt{759.7})\ /\ 2\pi 270$
(here, f =270Hz for low frequency reactive muffler)
0.4 ft ≤ L ≤ 2.04 ft
From the 1st method, L = 20 inch = 1.67 ft.
So the condition of 0.4 ft ≤ 1.67 ≤ 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

5.4 Tailpipe 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 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.

6. 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 SO_x is mixed in water, it form SO_2, SO_3, SO_4, H_2SO_4, 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 PH and Carbonates at higher PH. 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 NO_x

The Nitrogen in water under goes Oxidation to form ammonia, Nitrate, Nitrite, Nitric acid. This synthesis of protein and amino acids is affected by Nitrogen. Nitrate usually occurs in trace quantities in surface water.

7. RESULTS AND DISCUSSION

For testing of aqua silencer we used four stroke petrol engine.

Fig 7 :- Set up of Aqua-silencer

Fig 8:- Set up of Aqua-Silencer

The experimental results obtained were as follows.

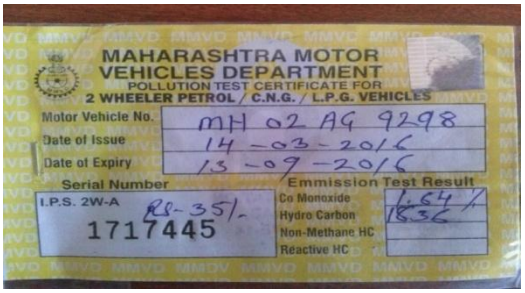

Fig 9:- PUC of Ordinary Silencer

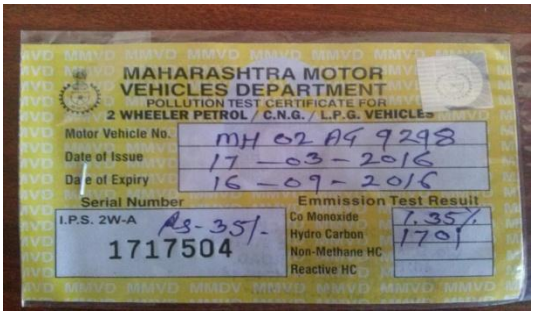

Fig 10:- PUC of Aqua – Silencer

	Prescribed Standard CO(%)	Measured level CO(%)	Prescribed Standard HC(ppm)	Measured level HC(ppm)
Ordinary Silencer	3.50	1.64	4500	1836
Aqua Silencer	3.50	1.35	4500	1701

Table. 3: Experimental Results

8. ADVANTAGES

1) No vibration when the engine is running.
2) Start the engine easy.
3) Control emission and noise in greater level.
4) Carbon is precipitated.

9. DISADVANTAGES

1) Lime water filling is required once in a year
2) Silencer weight is more compared to conventional silencer.

10. FUTURE SCOPE

Automobiles emissions have been increasing concern in recent years over. The engine emission contains various air pollutants almost all of which are toxic in nature. Some

of them include CO, CO_2, NO_X and Hydrocarbon removal of these pollutants is selected for the present study. Several expensive techniques are available all over the world but they are not applicable due to its high cost. Since adsorption technique in aqua - silencer is less expensive, it has been selected for the present study using some cost reliable chemicals as an effective adsorbent. Therefore the objective of the present work was to test the capability of some chemicals in removing harmful air pollutants. Various researches are going on to evolve an aqua silencer which can be fitted in to automobiles without effecting its aerodynamics properties and efficiency.

11. CONCLUSION

We have observed that the emission of ordinary silencer for HC and CO are 1836 and 1.64 respectively whereas the emissions of aqua-silencer are 1701 and 1.35 respectively which proves that the emissions are reduced by using an aqua-silencer.

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APPENDIX A NOMENCLATURE

L- Chamber length in m or inch
R_{ads} - Adsorption rate
k' - Rate constant
P - Partial pressure in N/m^2 or pascal
m -mass of one molecule
T -Temperature in Kelvin
λ -Wavelength of sound
C -Velocity of Light in m/s
^oR - absolute temp. in renkine
f -Frequency of sound (Hz)

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