

A Review on Design and Development of Aqua Silencer

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Abstract-Instantly, a like pollution has become a greatest threat in the world. It is important from the public health point of view, because Polluted air causes physical ill effects. Increasing toxic pollutant in the air has focused the world's attention on the need of reducing it. The main pollutants contribute by automobiles are carbon monoxide, unburned hydrocarbon, oxides of nitrogen and Lead. Aqua silencer is used to reduce harmful pollutants and noise levels. Since water is used in this silencer it has been named as Aqua silencer. Aqua silencer is cheaper, effective and easy to install.

Keywords: Aqua Silencer; Pollutant; Air Pollution; Emission; Noise

I. INTRODUCTION

Every individual needs to get fresh and pollution free environment. An aqua silencer System is intended to switch typical single unit engine silencers on board structures. With its lightweight and slender style, it optimizes the whole system for low noise and reduced backpressure. The reasons why we choose aqua silencer is, in nowadays the pollution causes physical unwell effects to the mortals and additionally the environment. Automobile gases like carbon dioxide and unburnt hydrocarbons contributes majority of air pollution. Other pollutant gases like oxides of nitrogen, oxides of sulphur and lead are also present in exhaust gases of automobiles. Aqua silencer is used to reduce these gases. It is fitted to the exhaust pipe of the engine. Water can reduce the sound level intensity than air or atmosphere. Activated charcoal layer is used to control emission of harmful gases because of its highly porous nature and extra free valences of carbon atom. Aqua silencer is easy to install and there is no need of catalytic converter. Aqua silencer is one of

the important methods for effective reduction of toxic gases and noise.

A Aqua Silencer

In aqua silencer, there are 4 to 5 perforated plates are installed. The perforated plate consists of different diameters. The purpose of providing different diameter holes is to break up gas mass to form smaller gas bubbles. The perforated plate of different diameter is shown in fig.3. Generally 4 sets of holes are drilled on the perforated plate. After passing through perforated plate it goes through a layer of activated charcoal is provided and further a glass wool and felt filter covers it. The whole unit is then placed in a water container. A small opening is provided at the end 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.

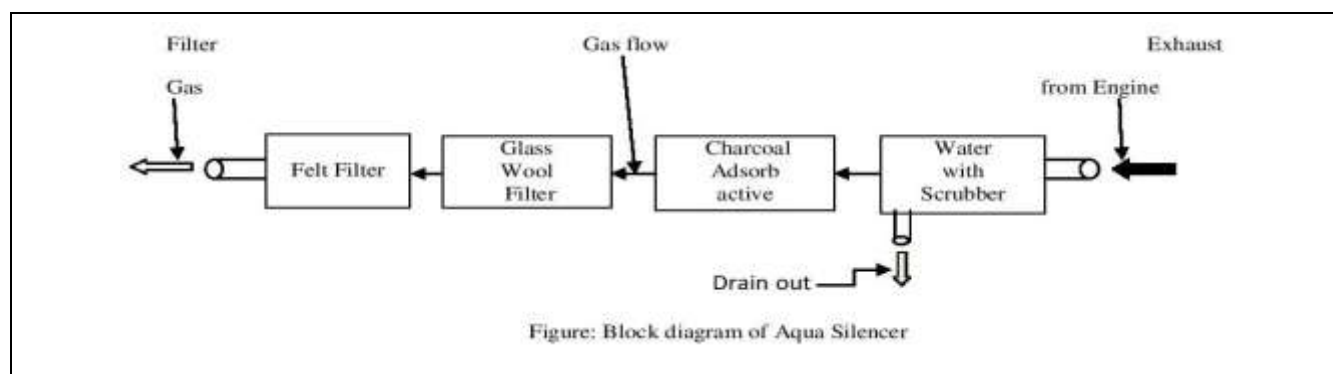


Figure: Block diagram of Aqua Silencer

Fig.1 Block diagram of Aqua Silencer

1) parts of Aqua Silencer:

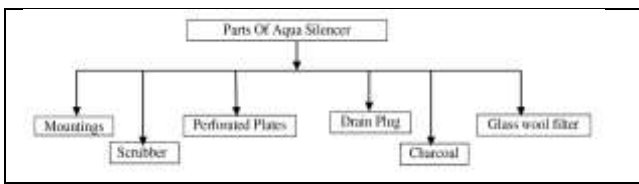


Fig.2 Block diagram of Parts of Aqua Silencer

a) Perforated Plate:

The perforated plate converts high mass bubbles into low mass bubbles, when exhaust gases enters the Aqua silencer. After that they pass through activated charcoals which again purify the gases. It is highly porous and porous extra free valences so it has high adsorption capacity. Some of the gases may dissolve in to the water and remains passes through the activated charcoals and finally opening it exhaust gases escape throughout the atmosphere. Hence aqua silencer reduces large amount of toxic gases and noise.

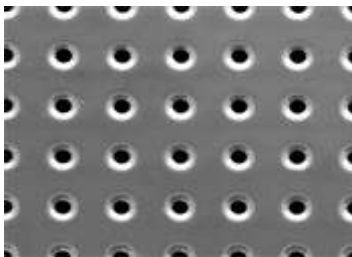


Fig.3 Perforated Plate

b) Charcoal Layer:

The charcoal layer has more adsorbing capacity because of its more surface area. Its surface area gets increases when it is produced by heating the charcoal above 1500 °c for several hours in a burner. It is also known as activated charcoal.



Fig.4 Charcoal Layer

c) Lime powder:

Saturated solution of calcium hydroxide is known as Lime water. Some amount of Calcium hydroxide Ca(OH)_2 is soluble in water (1.5 g/L at 25 °C). Pure limewater is crystalline, odorless and colorless. Limewater is prepared

by stirring allowable calcium hydroxide in pure water, and filtering off the allowable insoluble Ca(OH)_2 . When calcium hydroxide particles dissolve in pure water then it looks like milky, hence its name known as milk of lime. It is an alkaline solution (with a pH of 12.3).

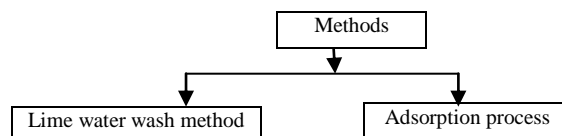


Fig.5 Lime powder

TABLE.I PROPERTIES OF LIME

Molecular formula	Ca(OH)_2	Solubility in water	0.189 g/100mL (0°C) 0.173 g/100mL (20°C) 0.066g/100mL (100°C)
Molar mass	74.093 g/mole	Solubility product, K_{sp}	4.68×10^{-6}
Appearance	White powder	Solubility	Soluble in glycerol and acids Insoluble in alcohol
Odor	Odorless	Acidity (pKa)	12.4
Density	2.211 g/cm ³ , solid	Basicity (pKb)	2.37
Melting point	580°C (loses water)	Refractive index (nD)	1.574

2) Methods to Avoid Water Pollution in Aqua Silencer:



a) Lime Water Wash Method:

The water is treated with the calculated quantities of slaked lime. Lime can neutralize any acid present in the water, SO_2 ; gases are removed from the flue gases forming calcium sulphite. The precipitates dissolved carbon dioxide as calcium carbonate and converts bicarbonate ions into carbonates^[7].

➤ *Effects of dissolved gases on water:*

The water is a best absorbing medium to use in silencer for dissolve toxic gases in water and reduce it completely. After these gases dissolved in water they form acids, carbonates, bicarbonates etc.

- *Action of dissolved SO₂:*
When SO_x is mixed in water, it form SO₂, SO₃, SO₄, H₂SO₄ i.e. sulfur Acid (H₂SO₃), it forms Hydrogen Sulphide which causes carious egg smell, acidify and corrosion of metals.
- *Action of dissolved CO₂:*
The dissolved carbon dioxide forms

Carbonates and Bicarbonates at lower and higher pH. This levels in between 40-400 mg/lit. When carbon dioxide mixes with water it form Carbonic acid and it is corrosive to metals and also causes green house effect.

- *Effect of dissolved NO_x:*
The NO_x in exhaust gas under goes Oxidation to form Nitrate, Nitrite, Nitric acid, ammonia. This synthesis of protein and amino acids is affected by Nitrogen. Nitrate usually occurs in trace quantities in exhaust gas.^[10]

➤ *Equations:*

TABLE.II EQUATIONS^[8]

Eq. No	Chemical Reactions	Description
(1)	$NO_2 + 2H_2O \rightarrow 2 HNO_2 + 2HNO_3$ (Diluted)	The NO _x is obnoxious product of combustion – the oxides of Nitrogen. Nitrogen will be absorbed to a larger extent by water.
(2)	$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$ $Ca(OH)_2 + 2HNO_2 \rightarrow Ca(NO_2)_2 + 2H_2O$	In scrubber tank a small amount of limewater is added, this reaction will takes place.
(3)	$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$ $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$	Calcium carbonate will precipitate, when the carbon-di-oxide present in the exhaust gas and comes in contact with the limewater. The calcium carbonate when further exposed to carbon-di-oxide, calcium-bi-carbonate will be precipitated.
(4)	$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 + H_2O$	The sulphur-di-oxide present in the Diesel Exhaust also reacts with the limewater. But the small trace of sulphur-di-oxide makes it little difficult to measure the magnitude of the chemical reaction, accurately. This equation gives the chemical reaction and calcium sulphite will precipitate.
(5)	$CaCO_3 + SO_2 + H_2O \rightarrow CaSO_3 + CO_2 + H_2O$	From calcium carbonate, calcium sulphite will precipitate and CO ₂ will be by-product. Because of the small percentage and SO ₂ presence, the liberation of Carbon dioxide is very less. But the liberated CO ₂ will again combine with CaCO ₃ to form calcium bicarbonate.

TABLE.III ADVANTAGES AND DISADVANTAGES

Sr.No.	Advantages	Disadvantages
a)	Detoxification	Amount of neutralization capacity is limited
b)	Maximum sound reduction capacity	it is very difficult to handle
c)	CO is reduced 60 to 70%	Bridging and form are formed
d)	High toxic gases reducing capacity	it is expensive
e)	Lime water highly chemically reacts with the exhaust gases from the engine	Regeneration is possible
f)	It release much less polluted gases to the environment	Lime in any form it is difficult to handle

b) *Adsorption process:*

Activated charcoal possesses high adsorption capacity because of its granular or powdered form. As it is highly porous and possess free valances. Activated carbon is mainly used for the removal of taste and odorous from the public water supplies. Because it has excellent properties of attracting toxic 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.^[7]

TABLE.IV ADVANTAGES AND DISADVANTAGES

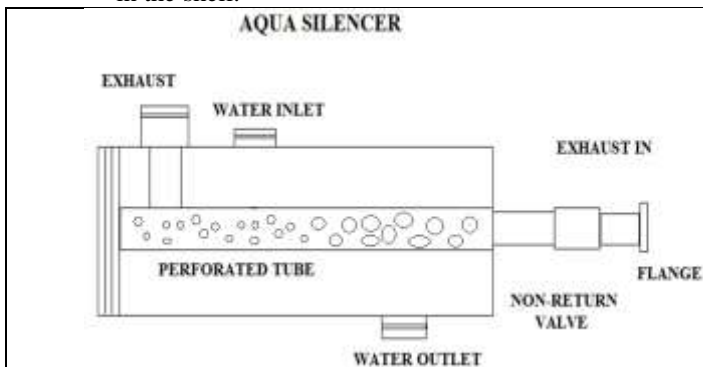
Sr.No.	Advantages	Disadvantages
a)	It increases the coagulation power of the process	Only substance with a high molecular weight and low water solubility are better absorbed
b)	The excessive dose of activated carbon is not harmful	Temperature influence the effectiveness of adsorption
c)	The treatment process is very simple and it requires nearly no skill	Large adsorbent quantities are needed
d)	The efficiency of removing color, odor and taste is quite high	High investment and operational cost required
e)	It can be easily regenerated	Routinely intravenous solutions, serums and antibiotics are required
f)	It has excellent properties of attracting gases	

II. REVIEW

A *Keval I. Patel et al [1]:*

The researcher made a complete study of how actually an aqua silencer works and made conclusions accordingly. The use of aqua silencer in reduction of toxic gases and noise and the benefits that this silencer can give by their use is explained in this extract.

- 1) *Analysis of the toxic gases and noise reduction system of aqua silencer:* In this first experimental study only the toxic gases and noise reduction system was under consideration
- a) *System Description:* The system under study consists of three units
- a perforated tube
 - a charcoal layer
 - water
- b) *Experimental Procedure:*
- First 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.
 - The charcoal layer is pasted over the perforated tube.
 - Bead Activated carbon is used as a charcoal layer.
 - 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.
 - The water inlet, outlet and exhaust tube was provided in the shell.



- c) *Method:*
- Adsorption method
- d) *Result:*
- Sound is reduced
 - CO is reduced 60 to 70 % compared to ordinary silencer
 - Engine efficiency increases with increase in flow rate of fluid
 - It has Low cost
- e) *Conclusion:*
- This experiment gives an effective way to reduce emission gases from the engine exhaust using perforated tube and charcoal.
 - Use of water as a medium the sound lowered and activated charcoal in water control the exhaust emission to a greater level and increases its efficiency.
 - Energy efficiency increases with increase in flow rate of back pressure (engine exhaust in the experiment under consideration).

It gives smokeless and pollution free emission.

- B *Akhil Anil Kumar et al[2]:* The researchers did a complete investigation and analysis of how AQUA SILENCER can affect the noise and toxic emission reducing capacity of an engines and explained the applications of engines with aqua silencer. A complete study of aqua silencer was made which included analysis of their work, structure and also their toxic emission and noise reduction capacities. Performance comparison of simple silencer, silencer with activated charcoal and silencer with activated charcoal and lime water was made. Aqua silencer is thermally effective and technically feasible for use as reduction noise and toxic emission of engine but certain improvements in the working of aqua silencer to fit in the application with the engine exhausting unit is essential. The study was done in Research methodology which included a study of methods, performance simulation and cost evaluation.

a) *Method:*

- Lime water

b) *Material Specification:*

- Perforated tube with activated charcoal

- Aqua silencer (box type)

- Engine exhaust first with aqua silencer and second without aqua silencer

c) *Conclusion:*

- Increase in less toxic emission and noise reduction capacity and efficiency by the use of aqua silencer.
- There is scope for further improvement in these systems to enhance the less toxic emission and noise reduction capacity.

- C *Sarath Raj et al [3]:* In this extract the researcher has given special attention towards performance and the cost analysis of aqua silencer. Aqua silencer is tested with different engines. General study is made on aqua silencer irrespective of them being used with engine or any other noise and toxic emission reducing devices. The effect of aqua silencer with different engine (petrol, diesel) on the engine efficiency and the cost of the overall work are properly analyzed. Perforated tube with activated charcoal layer for absorbs toxic gases and dissolve into water is the experimental setup for this study. Engine's exhaust toxic gases reduction rate is calculated for this value of engine efficiency gain. On the basis of the value of different results of toxic gases reduction rates and the noise reduction rate, the final conclusions are drawn.

a) *Methods:*

- Adsorption method

b) *Material specification:*

- Toxic gas reduces in aqua silencer with normal water.

- Aqua silencer designed to reduce toxic gases and noise for almost working Hrs.
 - Aqua silencer's components (price equal to 8579 Rs).
- c) *Result:*
Share of different factors in the total life cycle cost
- Average lost energy price- 29.45%
 - Aqua silencer price - 0.06%
 - The CO and HC values are reduce 33% and 48% with twin filter aqua silencer.
- d) *Conclusion:*
- For having an optimum design work of the system should be considered as it has an important and major Share in the total work cost
 - A successful attempt of reducing the noise is made
 - Total work cost along with energy lost price is decreasing
- D *Parikshit K. Patel et al [4]:* Different types of silencer are used today for noise controlling and toxic emission reducing purpose. In this study we have been given complete information about CFD analysis and how the use of perforated tube has enhanced the thermal efficiency of an engine with water. All this experimental setup and study was been carried out in order to check the systems performance with the use of perforated tube in aqua silencer. The study aimed at bringing in ideas to reduce toxic emission and noise. The experimenter integrated an aqua silencer directly exhaust of engine and studied the effect of such an alignment of aqua silencer on this operating constant exhaust system. For this study charcoal layer which was directly wrapped around the perforated tube were selected and tested. The effects of the charcoal layer for absorbing toxic gases and dissolving in water were checked. Also description about the mesh characteristics of this type of applications with the use of perforated tube in aqua silencer is given. The aqua silencer's perforated tube with charcoal layer and water are used in this study.
- a) *Methods:*
- Adsorption method
- b) *Material specifications:*
- Integrated charcoal layer
 - perforated tube
- c) *Result:*
- Use of perforated tube's enhanced the systems performance
- More the perforated tube diameters lesser the turbulence and contour
- study on the aqua silencer's shows that the use of perforated tube with charcoal layer proved to be more beneficial
- d) *Conclusion*
- A successful attempt of reducing the sound is made
 - Use of perforated tube in aqua silencer has a great affect on the system
 - Perforated tube reduces the sound and kept the constant back pressure
- E *G Maruthi Prasad Yadav et al [5]:* The researchers made a complete study on performance of different types of silencers and analysis of how aqua silencer can work also explained the some applications with aqua silencers. A complete study of aqua silencer was made which included analysis of their characteristics, performances and also their emission tests. Performance comparison of diesel engine with and without aqua silencer was made. Aqua silencer is thermally effective and technically feasible for use as noise and toxic gases reduction. Tests were performed to investigate the effect of black smoke and No_x emissions and sound from exhaust gases. It was found that after implementing the aqua silencer engine tended to eliminate No_x emissions and sound completely. The study was done in two parts 1) performance of aqua silencer. 2) Research methodology which included a study of characteristics, performance and their emission test.
- a) *Method:*
- Adsorption method
- b) *Material Specifications:*
- Aqua silencer (box type).
 - Engine exhaust first without aqua silencer and second with aqua silencer.
- c) *Conclusion:*
- Reduces high sound intensity by the use of aqua silencer.
 - By using an aqua silencer carbon monoxide (CO) emission is reduced up to 53%, unburned hydro carbon (UBHC) reduced up to 41% and CO_2 emission reduced up to 44% than that of existing system.

TABLE.V REVIEW

Sr no	Name of researcher	Method used	Materials used	Conclusion
A	Keval I. Patel	Adsorption method	Activated charcoal with perforated tube	This experiment gives an effective way to reduce emission gases from the engine exhaust using perforated tube and charcoal.
B	Akhil Anil Kumar	Lime water	perforated tube	There is scope for further improvement in these systems to enhance the toxic emission and noise reduction capacity
C	Sarath Raj	Adsorption method	Charcoal layer	A successful attempt of reducing the noise is made also total work cost along with energy lost price is decreasing
D	Parikshit K. Patel	Adsorption method	Integrated charcoal layer with perforated tube	Use of perforated tube in aqua silencer has a great affect on the system
E	G Maruthi Prasad Yadav	Adsorption method	perforated tube	Reduces high sound intensity by the use of aqua silencer and gives smokeless and pollution free emission

III. CONCLUSION

In this review paper the complete focus was given on the study about the use of aqua silencer enhances the reduction of noise and toxic emission and all the various applications. There is tremendous progress in the field of reduction of toxic emission but still there is scope of further advancement in this field. By using perforated plates the fuel consumption remains same as conventional system. By using water as a medium the sound can be lowered and also by using activated charcoal in water we can control the toxic emission to a greater level. In aqua silencer the water contamination is found to be negligible. It gives smokeless and pollution free emission and also it is less expensive. It can be used for vehicles and also can be used in industries.

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