Design and modification of aqua silencer

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Abstract- Hence the name, Aqua Silencer is a modified version of a traditional silencer designed to reduce the noise generated by dampening techniques that use water as well as the harmful emissions released into the atmosphere from an IC engine's exhaust. With the use of straightforward yet efficient modifications to the silencer's design and construction, it uses inexpensive chemicals like water, lime water, and activated charcoal to lower noise and harmful emission levels.

Air pollution is one of the main risks to society and the environment, having negative consequences on both the environment and people. The gases that cars emit, such as carbon dioxide and unburned hydrocarbons, are the primary causes of air pollution. In order to mitigate this significant contributor, the study concentrated on altering traditional silencers by presenting a modified Aqua silencer that reduces the production of this type of pollutant.

The engine's exhaust pipe is slightly modified to accommodate the aqua silencer, which is installed similarly to a traditional silencer.

The layers of activated charcoal regulate the emission in the modified aqua silencer. The silencer effectively absorbs dangerous gasses from the atmosphere, maintaining a car's environmental friendliness. The issue of noise pollution is also addressed with aqua silencers, which reduce the volume of sound generated in water by using tiny sprockets in the water molecules to reduce the amplitude of the sound.

INTRODUCTION

1.1 Background:

After industry, vehicles are a significant source of pollution in the environment. From the perspective of public health, air pollution is a major problem. Unexpected physiological and physical impacts on human health are caused by polluted air. The addition of undesired material to our atmosphere, which will quickly affect the life of living organisms on our planet, is known as air pollution.

Lead, nitrogen oxides (NOx), unburned hydrocarbons (UBHC), and carbon monoxide (CO) are the primary pollutants released by engine exhaust. Two groups of emissions can be distinguished. Emissions that are 1) invisible and 2) visible. The following are the main emissions in exhaust gas.

1. Invisible emission.
a) Un-burnt hydro-carbon (HC)
b) Oxides of carbon (COX)
c) Oxides of sulphur. (SOX)
d) Oxides of nitrogen. (NOX)

2. Visible emission
a) Soot and Smoke (carbon particles)
b) Particulates

It is impossible to claim that automobiles alone are the only source of air pollution. Therefore, it is imperative that significant efforts be made to protect our environment from deprivation. Other sources of pollution include electric power generating stations, industrial and domestic fuel consumption, industrial processing, etc.

Power plants, cars, locomotives, and other manufacturing facilities all employ engines for different reasons. In the context of pollution, it is important to take into account both the noise generated and the air emissions. In homes or other places where noise poses a risk, the noise produced by these engines becomes a major worry. According to science, noise levels above 80 dB on average are dangerous for people. The exhaust and the noise generated by the engine's numerous elements rubbing against one another are the primary sources of engine noise. As a result, this kind of silencer captures engine emissions while releasing a significantly smaller amount into the atmosphere.

1.2 Design Considerations of the Study:

Carbon monoxide, sulfur dioxide, carbon dioxide, and other nitrogen oxides are present in the exhaust gas. The exhaust gas temperature will range from 500°C to 700°C when it is fully loaded. The design of the exhaust gas manifold, the size of the valve overlaps,

engine speed, the number of cylinders, the length of the exhaust gas flow channel, and other parameters all affect the exhaust gas pressure. For high-speed diesel engines, the exhaust gas manifold's design is crucial. To keep the exhaust gas pressure within the necessary ranges, the exhaust gas manifold is made to ensure that the gases exiting the cylinder flow smoothly before being released into the atmosphere. It is imperative that the back pressure be kept within safe bounds in order to retain the engine's optimal operating level. When introducing any modification to the exhaust system, the main consideration is not to increase the back pressure because doing so will significantly affect performance. If the back pressure is permitted to exceed the pre-determined level, the piston's effort for scavenging is greatly increased, and power is lost in doing so.

More specifically, an engine's combustion properties are all impacted by the engine's speed at a particular specific fuel consumption rate. Because of improper and incomplete combustion, there are more pollutants or unburned gasses as a result. This idea runs counter to the goal of implementing any technology whose only goal is to lessen the exhaust gas's extremely harmful characteristics. According to this study, if a system is implemented that lowers the exhaust gas's harmful properties, it shouldn't have any negative impacts. Therefore, adding any component to the system increases the flow path length and the flow resistance indirectly. Therefore, an increase in back pressure is unavoidable unless the component's design compensates for the magnitude increase. The water in the scrubber tank must be traversed by the exhaust gas in this investigation. In any event, the engine's outlet must be maintained below the scrubber tank's water level in order for the gas to flow through the water. For the gas to bubble through the water, it must not push the water. When exhaust gas is released from the engine due to the high temperature, some of the water particles that come into touch with it quickly change their phase from liquid to gaseous (i.e., steam), increasing the net mass of the exhaust gas flow per unit time. Care must be taken when constructing the system to avoid excessively raising the back pressure, which will impair engine performance. It is therefore imperative that a mechanism for measuring the system's back pressure be included so that it can be adjusted as needed. This improves the system's overall performance in addition to ensuring safety.[2]

1.3 What is Aqua Silencer?

Aqua silencer is one of the attempt taken in reduce the air pollution. It is fitted to the exhaust pipe of engine or system. These Silences is used to reduce the noise and control the emission of dangerous gases. In aqua silencer the main component perforated tube which consists of number of different diameter holes.

On board structures, an aqua silencer system is intended to take the place of traditional single unit engine silencers. It provides a limited target point while optimizing the complete exhaust system for low noise and maintains the back pressure at its current level thanks to its slim shape and relatively light weight. It is employed in IC engines to reduce noise and emissions. It is attached to the engine's exhaust pipe. Compared to sound produced in the atmosphere, sound produced underwater is less audible.

The primary cause of this is the tiny sprockets in water molecules, which reduce the amplitude and, consequently, the sound level. The activated charcoal layer has a high absorption capacity due to its high porosity and additional free vacancies, which allow for emission control. Using certain experimental chemicals inside the components, I will attempt to minimize the silencer's size without affecting the vehicle's weight.[3]

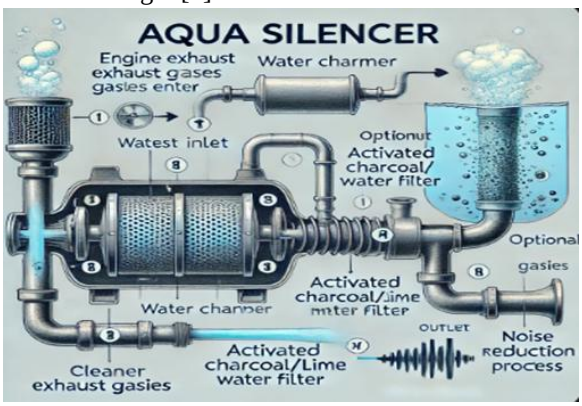


Fig 1.1:- Aqua silencer

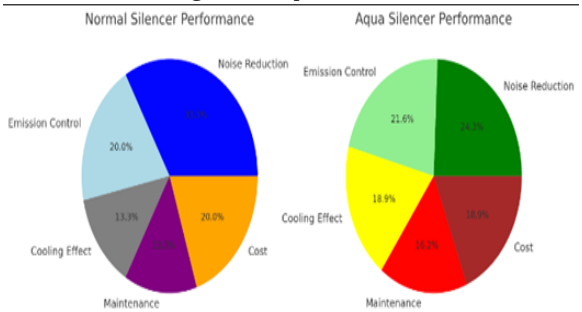


Fig 1.2:- Quick Comparision

LITERATURE REVIEW

[1] Keval.I. Patel: [June 2014] worked on a two-stroke gasoline engine to lower the noise and emission level using an aqua silencer. They claim that perforated tubes, which are fitted at the end of pipes, may contain holes with varying diameters. Because of the perforated tube's ability to reduce back pressure and noise, the holes of varying diameters are specifically designed to split up gas mass and create smaller gas bubbles. They claim that the sound and emission can be controlled more than with a traditional silencer. In particular, he studied carbon and discovered that it reduces carbon monoxide, which is extremely damaging to human health, by 60% to 70% when compared to a standard silencer.[4]

[2] M. A. Allen: [December 2015] Regulations for emission limitations are also enforced, and great efforts are being made to lessen the air pollution caused by gasoline and diesel engines. Additionally, future cars will have fuel consumption reductions of 40% or more due to advancements in gasoline and diesel engines and vehicle enhancements. The advancement of an engine's silencer unit is one example of such a development. An Aqua Silencer is useful in this situation. The primary function of an aqua silencer is to reduce noise and emissions from engine exhaust. It is essentially made out of a perforated tube that is placed near the engine's exhaust exit and may have holes with different sizes. This is done in order to create gas molecules with smaller diameters by dividing the larger ones. In theory, drilling is used to create four or more sets of holes in the perforated tube. A plug is used to seal the perforated tube's other end. After that, this device is set inside a container that has been filled to a specific level with water. A small diameter pipe transports the exhaust from the inside box to the exterior through a tiny hole in the lid. At the end of a perforated tube is a U-shaped pipe that serves as a nonreturn valve, preventing lime water or engine exhaust from flowing back into the engine. A portion of the gases dissolve in the water after passing over the layer of charcoal, and then the exhaust gases eventually escape into the atmosphere through the opening. The word "emission" refers to the entirety of undesirable gases and particulates that are discharged into the atmosphere or expelled by various sources. Examples include CO, CO2, NOX, and hydrocarbons. Vehicles and industrial engines are the primary source of air pollution, releasing gases such as carbon dioxide that are not burned. hydrocarbons. Carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), and sulfur dioxide (SO2) are among the pollutants that are produced in engine exhaust in addition to heat and water vapor. Particulate and Unburned Hydrocarbons (UBHC), Respirable combustible Dust (RCD). The above polluting contents in the engine exhaust are to be controlled by the Aqua Silencer.[5]

[3] Maruthi Prasad Yadav : Research on a four-stroke, multi-cylinder diesel engine with an aqua silencer was conducted by Maruthi Prasad Yadav et al. In the majority of applications, the final choice of an aqua silencer is determined by combining the anticipated mechanical, structural, aerodynamic, and acoustical performance with the cost of the final system. The model is then used to determine the performance and results. They come to the conclusion that although installing an aqua silencer reduces contamination, employing a regular silencer gradually increases it. They compared various silencers based on engine sound characteristics. Without any load, the sound level in an aqua silencer is 75 dB, compared to 83 dB in a standard silencer.

[4] Prem Sankar R: [August 2015] worked on a four-stroke, single-cylinder diesel engine to use an aqua silencer to lower the noise and pollution levels. They have constructed and tested an aqua silencer, using lime water and activated carbon (charcoal) to reduce noise and pollution. Lime water is used to absorb harmful gasses since they breakdown in water and produce acids and carbonates. They also tested an aqua silencer with lime water and discovered that it lowers the temperature inside the silencer. They claim that the Aqua Silencer uses the same amount of gasoline as a traditional silencer and is more efficient than one.[7]

[5] Ranjith Krishna: worked on a CI engine to reduce the emission of toxic gases using an aqua silencer. They used water and a layer of charcoal with a perforated tube assembly because the charcoal layer (activated carbon) has a high absorption capacity. Since sound waves have a smaller amplitude in water than in the atmosphere, water is employed to reduce noise levels. They have determined that aqua silencers lower emissions more than conventional silencers based on PUC testing.[8]

[6] Mankhair Ajay: Because the charcoal layer needs to be changed every three years, Mankhair Ajay used

titanium nanotubes in addition to the charcoal layer when working on the aqua silencer. Manganese, which makes up nanotubes, separates hydrogen molecules and traps exhaust gasses. A chemical sensor called the Ruthenium sensor is utilized to determine the water's quality. It transmits the signal to the control unit by acting as a transducer. A 12V electrical supply is provided to the control unit. After then, the Ruthenium sensor is turned on. A signal is now being sent. The water tub is presently filled with exhaust fumes. In addition to reducing noise, a water tub dissolves gas pollutants. Regeneration from hydrogen molecules is accomplished by nanotubes. In addition to reducing air and water pollutants, this silencer controls water and air pollution, it also reduces unwanted vibrations when the vehicle is in steady state.[9]

[7] P. Balashunmugam: and colleagues conducted an analysis in which they found that the lime stones' initial purpose was to lower the exhaust gas's hazardous elements through a chemical reaction. The flow of resistance is clearly impacted, and as a result, the engine's combustion characteristics will ultimately lead to the exhaust gas's higher levels of harmful chemicals. According to his research, the water in the scrubber tank itself can play a significant role in absorbing the unpleasant byproducts of combustion, such as nitrogen oxides, even though the introduction of the scrubber also increased the net length of the exhaust gas flow path, which is again against the original intent. After being released, NO is changed into NO2, which is extremely poisonous and mostly absorbed in water scrubber.

OBJECTIVE

The study aims to reduce emissions in auto-mobiles by controlling IC engine emissions, reducing noise, and reducing back pressure. The research focuses on adsorption techniques, using cheap chemicals as effective adsorbents. The project aims to test the effectiveness of an Aqua Silencer in minimizing air pollutants and reducing engine noise.

MATERIAL AND METHODOLOGY

4.1 Materials

4.1.1 Stainless steel

The project's materials are machinable and resistant to corrosion. Every component of the project is made of the same stainless steel material. Since the projects required drilling, grinding, and welding, the following factors are taken into account while choosing the material. Corrosion Resistance: Stainless steel is an alloy that resists corrosion because it contains chromium. Thus, the aqua silencer is made of stainless steel.

Electrical And Thermal Conductivity: Stainless steel is an excellent heat and electricity conductor and in relation to its weight is almost twice as good as copper. This has made stainless steel the most commonly used material to make for implementation of practical use.

S.NO.	COMPONENTS	MATERIALS
1.	Outer shell/cover/	Stainless steel
2.	Lime Water	Water and lime powder
3.	Perforated Tube	Stainless steel
4.	Non return valve	Steel
5.	Pipe	Stainless steel
6.	Activated Carbon	Charcoal

Reflectivity: Stainless steel is a good reflector of noticeable light as well as heat, and that together with its low weight makes it an ideal material for reflectors in, for example, light fittings or rescue blankets.

Ductility: Stainless steel is ductile and has a low melting point and density. In a liquid condition it can be processed in a number of ways. Its ductility allows products of Stainless steel to be basically formed close to the end of the product’s design.

Odorless: Stainless steel is the metal itself is non-toxic and releases no odours or taste substances which make it ideal for packing sensitive product’s design.

4.1.2Activated Charcoal

Activated carbon, also known as activated charcoal or activated coal, is a type of carbon that has been processed to possess numerous microscopic, low volume pores, hence enhancing the surface area available for adsorption or chemical reactions; the term 'activated' is occasionally replaced with 'active.' According to gas adsorption, one gram of activated carbon has a surface area of more than 450 m2 because of its high degree of micro porosity. High surface area alone can achieve an activation level high enough for practical usage, although additional chemical action frequently improves adsorption characteristics. Char is often the source of activated carbon, which is

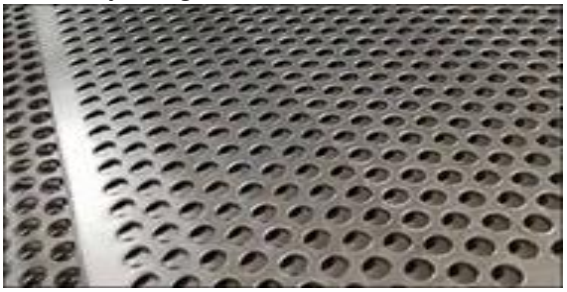
occasionally used as bio char. Activated carbon, also referred to as a "molecular sponge," is a substance with an extremely large surface area composed of millions of holes.

Properties of activated carbon:

- High surface area,
- Very low density and
- High adsorbing capacity (especially hydrocarbons)

4.1.3 Perforated Tube

There are several holes of varying diameters in the perforated tube. High mass bubbles can be changed to low mass bubbles using this technique. The perforated tube is covered with the layer of charcoal. Typically composed of stainless steel, perforated tubes feature holes punched or drilled around the outside. The primary purpose of these tubes is to lower the engine's backpressure because they are there to direct the flow. However, it is possible to increase the muffler's transmission loss with the right perforated tube design. Backpressure is necessary for a silencer to function. Losses from pipes, silencers, and terminations are included in the exhaust system's pressure drop. Cross flow perforated tubes are the most important part of any commercial muffler when it comes to backpressure, and the porosity of the perforations and the diameter of the hole in the tube are crucial factors. The backpressure drastically drops by 40% as the hole's diameter grows. Back pressure is remarkably affected by changes in hole diameter.



Perforated tube and plate

4.1.4 Charcoal Layer

Because the charcoal layer has a larger surface area, it can absorb more. Activated charcoal is the name given to this type of charcoal. It is made by burning charcoal in a burner above 1500 degrees Celsius for a number of hours. It gains more surface area. To make charcoal a more effective filter, it can be activated. A large variety of organic chemicals that are dissolved or suspended in gases and liquids can be easily adsorbed by activated charcoal. Activated charcoal can be used to eliminate the unwanted color that impurities generate in some industrial processes, such as the purification of sucrose from cane sugar. Additionally, it is utilized to absorb poisons and odors from gasses like air.[12]

Fig 4.2:- charcoal layer

4.1.5 Lime Powder

Lime water is a saturated calcium hydroxide solution. At 25 °C, a small amount of calcium hydroxide (Ca(OH)2) dissolves in water (1.5 g/L). Pure limewater has no color, no smell, and is crystalline. permitted calcium hydroxide is agitated in pure water, and the permitted insoluble Ca(OH)2 is filtered off to create limewater. The term "milk of lime" refers to the milky appearance that results from the dissolution of calcium hydroxide particles in pure water.[14] It has a pH of 12.3, making it an alkaline solution.

Fig 4.3:- Lime powder

4.1.6 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. Material selection of the outer shell is the crucial parameter because of the consideration of heat conductivity, corrosiveness and cost.

Requirement of good shell material:

- It should be heat conductive.
- The thermal conductivity of material must not be high enough so that it will liberate all of its heat and will cause less effective temperature for necessary reactions.
- The material should have good resistance to corrosiveness and erosion.

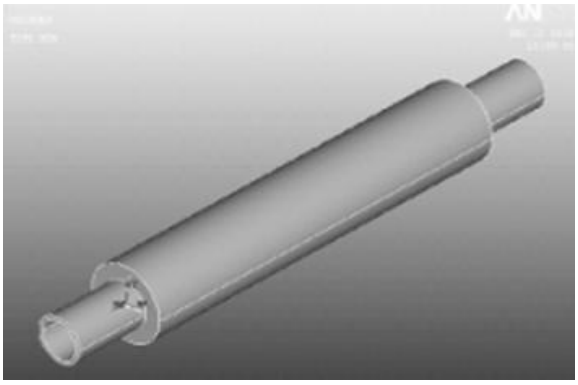


Fig 4.4:- Outer shell

4.1.6 Non Return Valve

The non-return valve is a mechanical device that typically permits just one direction of fluid passage. They have two ports: one for the media's input and one for its output. They are frequently referred to as "one way valves" or "non return valves" since they only permit media to flow in one direction.

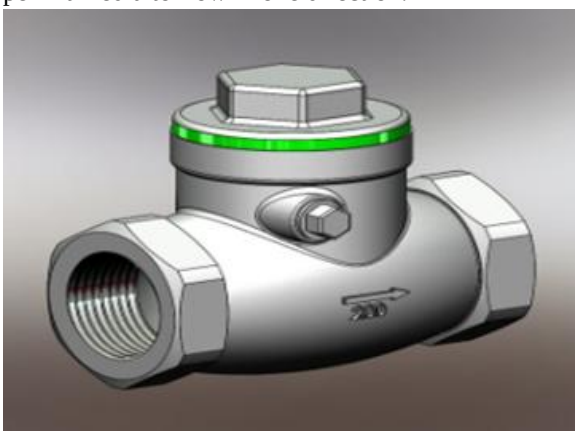


Fig 4.5:- Non-return Valve

4.2 Methods:

When exhaust gases enter the Pollution Control Aqua Silencer, high-mass bubbles are converted by the perforated tube. The gases then pass through a layer of charcoal, which cleanses them once more. It has a high absorption capacity due to its high porosity and additional free valences. Some of the gases may dissolve into the water after passing through the layer of charcoal, and then the exhaust gases will eventually escape into the atmosphere through the opening.

Methods to Avoid Water Pollution in Aqua Silencer:

4.2.1 Lime Water Wash Method

The water is treated with the calculated quantities of slaked lime. Lime can neutralize any acid present in the water, SO2 gases are removed from the flue gases forming calcium sulphite CaSo2. The precipitates dissolved carbon dioxide as calcium carbonate and converts bicarbonate ions into carbonates.

- 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 SOx 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 greenhouse effect.
- Effect of dissolved NOx:
  The NOx 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.[14]

4.2.2 Adsorption Process

Adsorption is the adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. This process creates a film of the adsorbate on the surface

of the adsorbent. This process differs from absorption, in which a fluid (the absorbate) is dissolved by or permeates a liquid or solid (the absorbent), respectively. Adsorption is a surface phenomenon, while absorption involves the whole volume of the material.

The term sorption encompasses both processes, while desorption is the reverse of it.

Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent or metallic) of the constituent atoms of the material are filled by other atoms in the material. However, atoms on the surface of the adsorbent are not wholly surrounded by other adsorbent atoms and therefore can attract adsorbates. The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorption (characteristic of covalent bonding). It may also occur due to electrostatic attraction.

A common adsorbent for organic materials and non-polar adsorbates, as well as for the treatment of waste gases and water, is activated carbon. It is helpful in eliminating taste and odorous contaminants from public water sources due to its strong adsorption capability and big micropore volume. When activated charcoal is powdered, it draws phenol-type contaminants, fine particles, and hazardous gasses, which makes it appropriate for coagulation with sedimentation. Because of this, the Pollution Control Aqua Silencer is a useful instrument for lowering pollution and noise.

In these chemical reaction involved is as follows:

Reaction:1

The obnoxious product of combustion is NOx – 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.

$$NO + 2HO2 \rightarrow 2HNO2 + 2HNO3 \text{ (Diluted)} \ldots (i)$$

Reaction:2

If a small amount of lime water is added to scrubber tank, the further reaction takes place as follows :

$$Ca(OH)2 + 2HNO3 \rightarrow Ca(NO3)2 + 2H2O$$

$$Ca(OH)2 + 2HNO3 \rightarrow Ca(NO2)2 + 2H2O \ldots\ldots (ii)$$

Reaction:3

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

$$Ca(OH) + CO2 \rightarrow CaCO3 + H2O$$

$$CaCO3 + H2O + CO2 \rightarrow Ca(HCO3)2 \ldots (iii)$$

Reaction:4

The sulphur dioxide present in the diesel exhaust also reacts with the limewater. But the small trace of sulphur dioxide makes it little difficult to measure the magnitude of the chemical reaction, accurately. The following equation gives the chemical reaction and calcium sulphate will precipitate.

$$Ca(OH)2 + SO2 \rightarrow CaSO3 + H2O \ldots\ldots (iv)$$

Reaction: 5

$$CaCO3 + SO2 + H2O \rightarrow CaSO3 + CO2 + H2O \ldots (v)$$

From calcium carbonate, calcium sulphate will precipitate and CO2 will be a by-product. Because of the small percentage and SO2 presence, the liberation of Carbon dioxide is very less.But the liberated CO2 will again combine with CaCO3 to form calcium bicarbonate as mentioned in equation no. 5.[15]

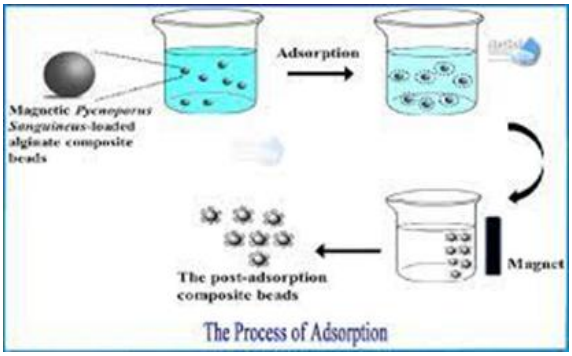


Fig 4.6:- Adsorption Process

"Construction & Working"

Installed in the exhaust pipe, an aqua silencer is made out of a perforated tube, a layer of activated charcoal, and water. The holes in the perforated tube vary in diameter. To break up the gas mass into smaller gas bubbles, perforations of varying diameter are provided. The perforated tube is typically drilled with four sets of holes. A stopper closes off the tube's other end. A coating of activated charcoal is placed around the outside of the perforated tube and coated with metallic mesh. After that, the complete device is put in

a container of water. A drain plug is included at the bottom of the container to allow for frequent cleaning, and a little aperture is supplied at the top to dispose of exhaust gasses. Additionally, a filler plug is installed on the container's top. A non-return valve is installed at the exhaust pipe's entrance to stop gases and water from flowing backward.

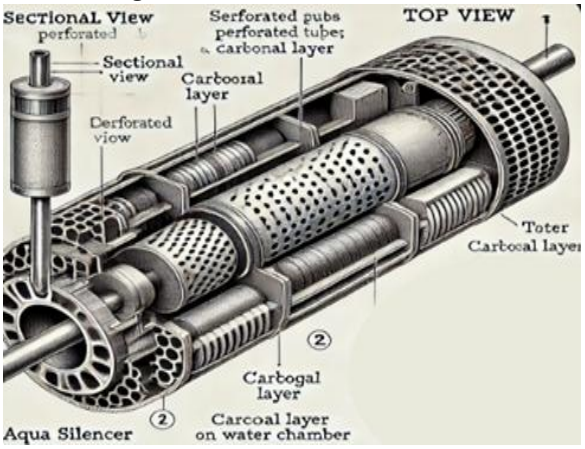


Fig 5.1: - Aqua-Silencer

After passing through the charcoal layer, which exonerates the gases, the exhaust gases enter the aqua silencer and are accepted into the perforated tube, which transforms high mass bubbles into low mass bubbles. This layer has a high absorption capacity because it is extremely porous and has additional free valences. Some of the gases may dissolve in the water after passing through the layer of charcoal, and then the exhaust gases are released into the atmosphere through the opening. Aqua silencers hence lessen pollutants and noise.[16]

DESIGN AND CALCULATION

6.1 Design:

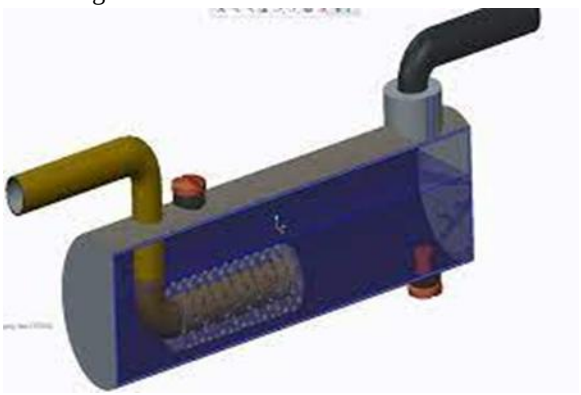


Fig 6.1:- Prototype Design

6.1.4 Dimensions Of Components:

Outer shell:

- Diameter - 150 mm
- Length - 18 inch = 457.2 mm
- Thickness - 5 mm

Inlet pipe diameter – 50 mm
Perforated tube diameter – 50 mm
Perforated tube holes – 8-10 mm
Charcoal layer shell :

- Diameter – 50.2 mm
- Thickness – 25 mm
- Length – 8 inch = 203.2 mm

Buffel plate diameter – 149.8 mm
Water inlet & outlet valve diameter – 10 mm

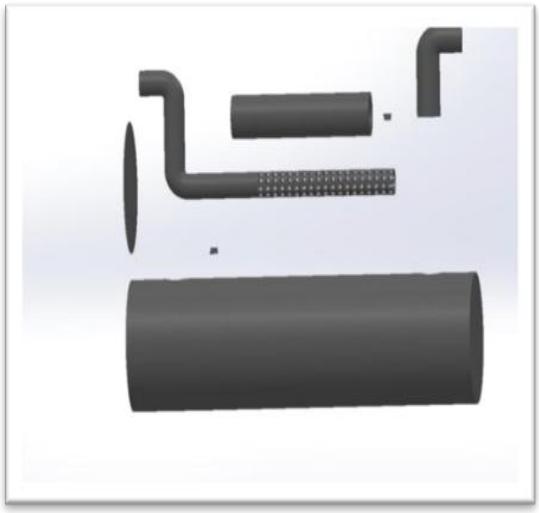


Fig 6.2 :- Sectional view of aqua silencer

Fig 6.3 :- Top view of aqua silencer

Fig 6.4 :- Front view of aqua silencer

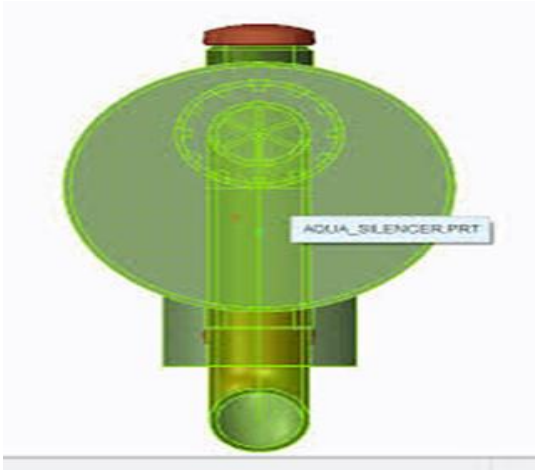


Fig 6.5 :- Side view of aqua silencer

6.2 Calculation And Result :

6.2.1 Calculation :

First Calculation:	Second Calculation:
Engine Specifications Model: Hero Honda Splendor	Engine Specifications Model: Hero Honda Splendor
Muffler Diameter (D) = 90 mm	Muffler Diameter (D) = 98 mm
Stroke (L) = 49.5 mm	Stroke (L) = 49.5 mm
No. Cylinders (n) = 1	No. Cylinders (n) = 1
Engine power (P) = 6.15kw (8.36ps) @ 8000rpm	Engine power (P) = 6.15kw (8.36ps) @ 8000rpm
Max. RPM (N) = 8500 rpm	Max. RPM (N) = 8500 rpm
Allowable back pressure for muffler = Not available (in H2O)	Allowable back pressure for muffler = Not available (in H2O)
Transmission Loss Noise target (muffler) = 30 dB.	Transmission Loss Noise target (muffler) = 30 dB.
To find fundamental frequency Cylinder Firing Rate (CFR) CFR = RPM/120 for 4-cycle engines CFR = 8000/120 = 66.66Hz	To find fundamental frequency Cylinder Firing Rate (CFR) CFR = RPM/120 for 4-cycle engines CFR = 8000/120 = 66.66Hz
Engine firing rate (EFR) EFR = No. of cylinder x Cylinder firing rate EFR = 1 X 66.66 = 66.66Hz	Engine firing rate (EFR) EFR = No. of cylinder x Cylinder firing rate EFR = 1 X 66.66 = 66.66Hz
Internal configuration of muffler and concept design Diameter of muffler calculated as $Vm = (\pi/4) \times D^2 \times L$ Here, we take L= 350 mm after studying various muffler lengths of similar engine mufflers and overall space available on a motorcycle for mounting of a muffler and hence we select the same length. $Vm = (3.14/4) \times (90)^2 \times (0.350)$ = 0.002225475 Liters.	Internal configuration of muffler and concept design Diameter of muffler calculated as $Vm = (\pi/4) \times D^2 \times L$ Here, we take L= 350 mm after studying various muffler lengths of similar engine mufflers and overall space available on a motorcycle for mounting of a muffler and hence we select the same length. $Vm = (3.14/4) \times (98)^2 \times (0.350)$ = 0.002638699 Liters.
As no. of cyl = 1 for hero splendor Silencer Volume (Vm) = Factor* x Consider Volume 0.002225475 = 25 X V V = 0.000089019 Lit. V = 89.019 mm^3 {*Assumed Factor = 25 } For volume of silencer the factor should be at least 12 to 25 times the volume to be considered. Volume can be changed depending on the space constraint.	As no. of cyl = 1 for hero splendor Silencer Volume (Vm) = Factor* x Consider Volume 0.002638699 = 25 X V V = 0.00010554796 Lit. V = 105.54769 mm^3 {*Assumed Factor = 25 } For volume of silencer the factor should be at least 12 to 25 times the volume to be considered. Volume can be changed depending on the space constraint.

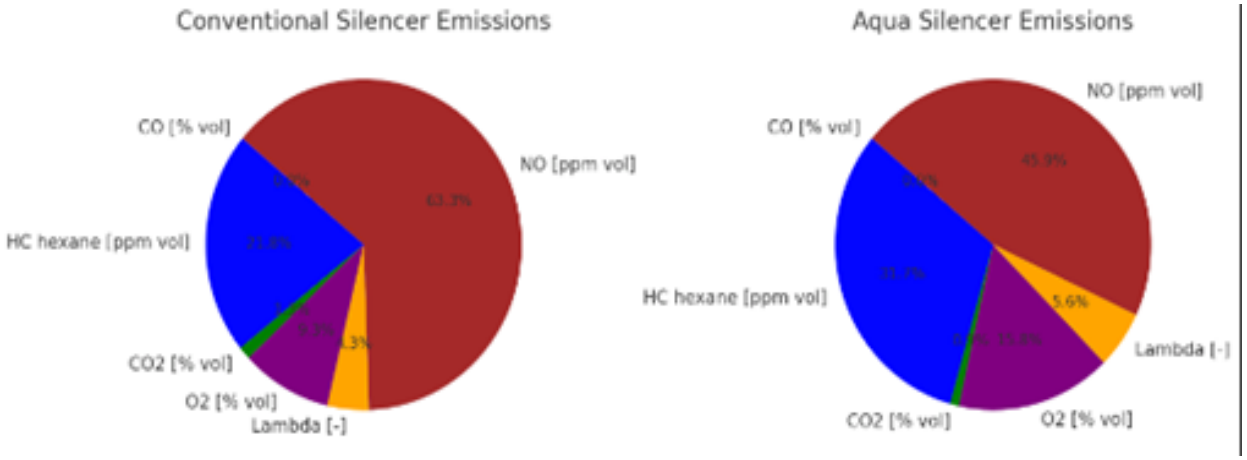
Volume to be consider for calculation Volume = (No. of cylinders) x Vs 0.000089019 = (1) x Vs Vs = 0.000089019 Lit. Vs = 89.019 mm^3	Volume to be consider for calculation Volume = (No. of cylinders) x Vs 0.00010554796 = (1) x Vs Vs = 0.00010554796 Lit. Vs = 105.54769 mm^3
Muffler volume calculations Swept volume (Vs) = (π x d^2 x L)/4 0.000089019 = (3.14/4) x d^2 x 49.5 d^2=2290.909091 d = 47.86 mm d = 48 mm	Muffler volume calculations Swept volume (Vs) = (π x d^2 x L)/4 0.00010554796 = (3.14/4) x d^2 x 49.5 d^2 = 2716.28282 d = 52.11 mm d = 53 mm

6.2.2 Result :

After researching different muffler lengths of comparable engine mufflers and the total amount of space on a motorcycle for mounting a muffler, we choose L= 350 mm in this case. Design of tail pipes For optimal flow characteristics and reduced flow resistance, tail pipe diameter and form are often chosen in accordance with OEM or manufacturer specifications. Hence, Tail Pipe Diameter = 23.48mm (From Hero Honda splendor).

Comparison between the conventional and aqua silencer reading

Parameters	Conventional Silencer	Aqua Silencer
CO[% vol]	0.06	0.03
HC hexane[ppm vol]	41	38
CO_2[% vol]	2.40	1.10
O_2[% vol]	17.42	18.99
Lambda[*]	7.989	6.773
Lambda constant Hev	0.000	0.000
Lambda constant Oev	0.000	0.000
NO[ppm vol]	119	55
Vibrometer Reading (Avg)	113.66 db	113.66 db
Non-Methane Hydrocarbon (HC)	524 PPM	239 PPM



Noise Level Estimation

S.NO	Noise Level With Conventional Silencer[db]	Noise Level With Aqua Silencer[db] (Case 1)	Noise Level With Aqua Silencer[db] (Case 2)	Noise Level Reduction In Case 1 Wrt Conventional[%]	Noise Level Reduction In Case 2 Wrt Conventional[%]
1	104.5	88	85	15.78	18.66
2	103	87.8	85.4	14.7	17.08
3	105	89	89.1	15.24	18.06

FUTURE SCOPE

Naturally, there has been a growing worry in recent years about the rate at which industrial waste streams and transports are being discharged into the environment, as well as the release of harmful emissions into the atmosphere from industrial and automotive engines. The solution to lowering the harmful pollutants that engines release into the environment may lie in technological innovations like the Aqua Silencer.

As of right now, the Aqua Silencer is limited to heavy-duty vehicles and industrial engines. However, after considering the matter, research and development teams are working to develop and adapt the Aqua Silencer so that it can be installed in cars while maintaining or improving its aerodynamic qualities.

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