

## **DESIGN AND OPTIMIZATION OF AQUA-SILENCER**

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### **Abstract**

Engines are one of the major sources for generating mechanical power. There are worldwide applications like automobiles, industries, generators, aircrafts, etc. Along with power required, they also produce noise and gases as a by-product. These gases contribute to the air pollution which is a major concern these days. As automobiles or passenger vehicles contribute most to the air pollution hence we propose a simple, easy to assemble system which is aqua-silencer. An aqua-silencer is a device which uses activated carbon and water of lime to not just reduce the emissions but also noise level. It is connected at the exhaust of the engine. When gases pass through the system, the activated charcoal absorbs most of it and the remaining reacts with the lime water and hence emissions are reduced. As sound is less audible in liquid medium hence noise level is also reduced in the system. It is economic, easy to maintain and a sustainable device.

**Keywords:** Exhaust system, aqua silencer, activated carbon, emission control.

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### **1. Introduction**

I.C. engines are playing a vital role in road and sea transport, agriculture, mining and many other industries. Considering the available fuel resources and the present technological development, fuel is evidently indispensable. In general, the consumption of fuel is an index for finding out the economic strength of any country. In spite, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. In today's life the air pollution causes physical ill effects to the human beings and other species that are the part of our environment. The main contribution to the air pollution is by auto mobiles releasing the gases like carbon dioxide, unburned hydrocarbons, carbon monoxide, NO<sub>x</sub> and SO<sub>x</sub>. In order to reduce this type of gases from entering into atmosphere we can use aqua silencer. It is fitted to the exhaust pipe of the engine; Sound produced under water is less audible than it is produced in air. This is 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 lime water. Activated charcoal layer is highly porous and possesses extra free valences so it has high absorption capacity. Along with this, lime water chemically reacts with the exhaust gases from the engine and releases much less pollution to the environment. The noise and smoke level is considerably less than the conventional silencer and there is no need of catalytic converter separately. It is easy to install system, which proves to be economic and is also easily maintainable.

### **2. Working Principle**

When the exhaust gases enter the aqua silencer they are first passed through a layer of activated charcoal. The activated carbon used is of coconut shell as it has more life, highly micro-porous and hence, high absorption capacity. This layer purifies and reduces the contents of the gases through absorption. As activated carbon contains free valences and is highly porous it has very good absorption capacity. As remaining gases come out of the charcoal layer they enter lime water and chemical

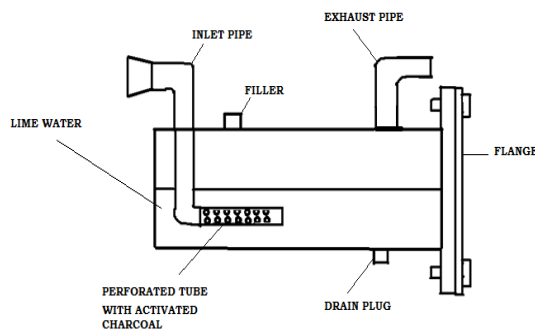
reactions take place. Using lime water instead of normal tap water gives a major advantage as it has high boiling point, provides more denser medium to absorb sound and also neutralizes all the acids formed. This behavior of lime water helps in improving the life of silencer.

When these exhaust gases dissolve in lime water, they form acids, carbonates, bicarbonates, etc. and the remaining gases are left out of the silencer. As sound is less audible in liquid medium compared to air the noise also reduces at the output. This is how aqua silencer helps in reducing the emissions and noise level of exhaust.

### 3. Constructional Features

Aqua silencer consists of following main components:-

1. inlet pipe
2. perforated tube
3. activated charcoal mesh
4. filler cap
5. drain plug
6. outer shell
7. flange
8. exhaust pipe



**Fig 1 Constructional features of aqua silencer**

#### 3.1 Inlet pipe

Inlet port is used to connect the aqua silencer to the exhaust pipe of engine with the help of reducer. It is permanently welded to the body of silencer. It is further connected to the perforated tube.

#### 3.2 Perforated tube

Perforated tube is a hollow tube with one end threaded and other end sealed. It has holes varying from 6mm to 11mm. These holes convert high mass bubbles to low mass bubbles and reduce back pressure on the engine. As it has threads on one end, it is easy to dismantle and clean the tube.



**Fig 2 Perforated tube**

#### 3.3 Activated charcoal mesh

A wire mesh filled with activated carbon is wound on the perforated tube. The exhaust gases are passed through the holes of tube, which are then absorbed by the micro-pores of activated carbon. This helps in reducing the emission of harmful gases.



**Fig 3 Coconut shell activated carbon**

#### 3.4 Filler cap and Drain plug

A filler cap is provided next to the inlet pipe which is used to fill the lime water in the silencer. Whereas a drain plug is located at the opposite end of the exhaust pipe which is used to drain the effluents and lime water when its life is over.

#### 3.5 Outer shell

Outer shell is the main body which supports all the components. It is the tank in which we fill the lime water and all the reactions happen there.

#### 3.6 Flange

A flange is used for maintenance purpose. The silencer can be easily cleaned from inside by removing the flange and the perforated tube can be easily changed.

#### 3.7 Exhaust pipe

The remaining unfiltered gases are let out from the exhaust pipe.

## 4. Virtual Analysis

The CAD model was drafted using CATIA software referring to the designed dimensions calculated as follows:-

Length of silencer = 400mm

Diameter of silencer = 136mm

Perforated tube length = 150mm

Inlet and outlet pipe diameter = 25.4mm

Filler cap and drain plug diameter = 31.75mm

Holes on perforated tube ranging from = 6mm to 11 mm

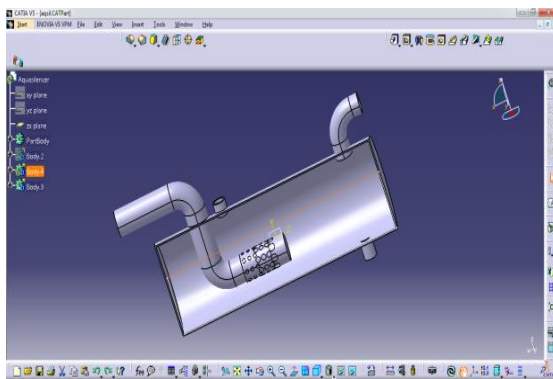


Fig 4 CAD draft of aqua silencer

Following were the results obtained after CFD analysis of the designed model:-

### 4.1 Pressure and velocity variation throughout the volume of cylinder

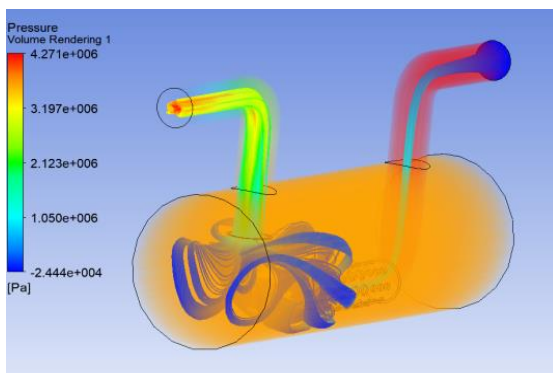


Fig 5 Pressure variation throughout the silencer volume

As it can be observed from the plot that pressure is in the mid range at the inlet of silencer, it is low in the perforated tube section and very high at the outlet of the silencer, it

can be concluded that the back pressure created on the engine comes out to be low and thus design is valid.

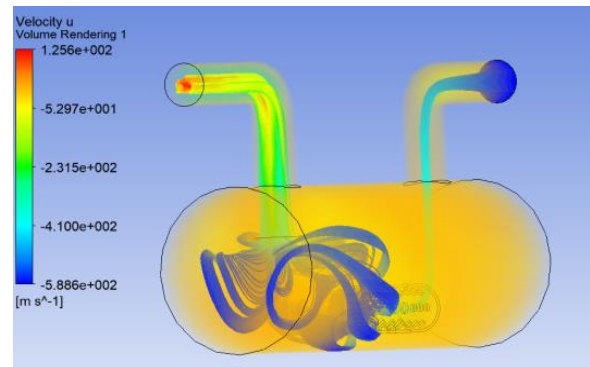
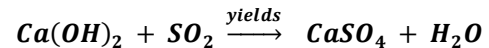


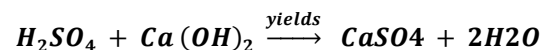
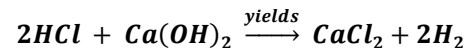
Fig 6 Velocity variation throughout the silencer volume

The velocity plot implies the flow rate of gases inside the silencer. It is observed that flow rate is slow near the perforated tube section which is due to the lime water present there. This improves the reaction time for the gases and help reduce the contents of CO, CO<sub>2</sub>, UBHC, etc. Both the plots validate the design by giving desired results.

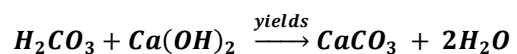
## 5. Effect of Lime Water on Gases



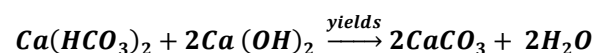
### 5.1 Neutralizes any acid present in water



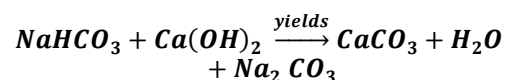
### 5.2 Precipitates bicarbonate as calcium carbonate



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### 5.4 Converts bicarbonate ions (Like NaHCO<sub>3</sub>, KHCO<sub>3</sub> etc.) into carbonates



## 6. Testing and Results

As the silencer is designed for Briggs & Stratton (19L232-0054 G1) four stroke 305cc petrol engine, the emission testing was conducted for the same. The complete setup

underwent the PUC test, which consisted testing in two parts:-

- i. Testing of engine without silencer
- ii. Testing of engine with silencer

In this way, it is easier to understand the behavior of silencer and to calculate the percentage reduction in contents of exhaust.

During the first test, the exhaust gases evolving directly from the engine exhaust were tested. The contents of emission can be observed in Table 1.

For this test, the Aqua-silencer was connected to the engine exhaust and emissions were measured with the gas analyzer. The reduced emission contents can be observed in Table 1. The following table is a detailed plot of emission contents observed during the complete test:-

**Table 1 Emission content result table**

Parameter	Without Aqua-silencer	With Aqua-silencer	Percent reduction (%)
CO	1.27	0.73	-57.48%
UBHC	22	0	-100%
CO <sub>2</sub>	3.8	1.3	-34.21%
O <sub>2</sub>	20.29	24.69	+21.68%

It can be observed that there is 100 percent reduction in UBHC, which is the most amongst of all, followed by CO which is -57.48% and CO<sub>2</sub> which is -34.21%. A notable increase in O<sub>2</sub> is also observed, which is +21.68%.

## 7. Conclusion

Aqua-silencer can be considered as a major emission control system which gives better results compared to conventional silencer in noise as well as emission reduction. Use of lime water and activated carbon makes it affordable and easy to use system. As the perforated tube has threads, it makes it easy for the user to remove it for cleaning and maintenance by removing the flange. It can be applied to both diesel as well as petrol engines in two-wheelers and four wheelers both.

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