

Design and Development of Aqua Silencer

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Abstract—Aqua Silencer is a modified version of a conventional silencer aimed at the reduction of toxic emission from the exhaust of an IC engine into the atmosphere and also to reduce the noise that is produced by damping methods which involves water and hence the name. It incorporates the usage of cheap chemicals like lime water, activated charcoal and water with the help of simple but effective change in the design and fabrication of the silencer to reduce the noise and toxic emission levels.

Index Terms—Aqua Silencer, Emission Control, Noise Reduction, Perforated Tube.

I. INTRODUCTION

It has been long observed that diesel engines play a crucial role in the transport industry, agriculture, mining and many other industries. Considering the available fuel resources and the present technological development, diesel fuel is evidently indispensable. In general, the consumption of fuel is an index for finding out the economic strength of any country. In spite of everything, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. An aqua silencer is used to control the noise and emission in IC engines. The reason why we opt for an aqua silencer is that, air pollution and noise pollution causes physical ill effects to human beings and also the environment. The main contributor of air pollution is automobiles releasing gases like carbon dioxide, unburned hydrocarbons, etc. In order to cut down on emission of these gases, we can use an aqua silencer. It is fitted to the exhaust pipe of the engine. Sound produced under water is less audible than in atmosphere. This is mainly due to presence of small sprockets in water molecules, which lowers its amplitude and 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 possess extra free valences so it has high absorption capacity and lime water chemically reacts with the exhaust gases from the engine and release much less polluted gases to the environment. The noise and smoke level is considerably less than the conventional silencer; there's no need of a catalytic converter and it is easy to install.

II. LITERATURE REVIEW

A lot of effort is being made to reduce the air pollution from petrol and diesel engines and regulations for emission limits are also imposed. Furthermore, developments in petrol and diesel engines, combined with improvements in the vehicles,

will make fuel consumption reduction of 40% or more in the future cars [6]. One such development is improvement of the silencer unit of an engine. This is where an Aqua Silencer comes into play.

An Aqua Silencer mainly deals with control of emission and noise in engine exhaust [9]. It basically consists of a perforated tube which is installed at the exit of the exhaust from the engine, which may have holes of variable diameters. This is done to divide the gas molecules of large proportions to form gas molecules of smaller diameter. Theoretically, four or more sets of holes are made on the perforated tube using drilling. The other end of the perforated tube is sealed using a plug.

A small coating of activated charcoal is provided all around the perforated tube using an inner box which holds the charcoal in place and separates the charcoal and lime water from the water in the Aqua Silencer. This unit is then placed in a container in which water is filled to a certain level. A small opening is provided on the lid of the inner box which carries the exhaust from it to the outside using a small diameter pipe. A U-bend of pipe is constructed at the end of perforated tube which doubles as a non-return valve which prevents the back flow of engine exhaust or lime water back into the engine. After passing over the charcoal layer, a portion of the gases dissolve into the water and finally the exhaust gases escape through the opening in to the atmosphere [1].

'Emission' is a term that is used to describe the totality of undesired gases and particulates which are released into the air or emitted by numerous sources. Its amount and type change with changes in the industrial activity, technology, and a number of other factors, such as air pollution regulations and emissions controls [6].

In addition to heat and water vapor, the pollutants formed in engine exhaust are,

- Carbon monoxide (CO)
- Carbon dioxide (CO₂)
- Oxides of Nitrogen (NO_x)
- Sulphur dioxide (SO₂)
- 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].

Causes of Smoke:

The main cause of smoke is incomplete combustion of fuel inside the combustion chamber. Two main reasons for incomplete combustion are incorrect air – fuel ratio and improper mixing.

These might result due to engine design factors, such as injection system characteristics, the induction system, governor control, the fuel used, and the engine rating.

- Injection system
- Rating
- Fuel
- Load
- Engine type and speed
- Fuel – air ratio

We know that in addition to harmful emission, engines also produce a very high amount of noise. Industrialization, together with the needs of our modern society for various machines for Human comfort, fast travel and appliances for routine jobs in homes and offices, has led to increase in the levels of noise pollution almost everywhere. The harmful effects of noise are well known [8].

Exposure to noise causes detrimental effects on neuro-endocrine, cardiovascular, respiratory and digestive systems. Chronic exposure to noise causes fatigue and interferes with concentration, thus reducing work efficiency [10].

The basic principle of using water in reducing noise is that sound produced under water is less audible than in atmosphere. This is mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level [9].

III. OBJECTIVE OF THE PROJECT

There has been an increasing concern in recent years over the increasing of transportation and discharge of industrial waste waters into environment. The engine emission contains air pollutants and other species. Almost all pollutants are toxic in nature. Some of the examples are CO, CO₂, NO_x, and Hydrocarbon [5]. Hence, removal of these pollutants was selected as the primary concern. There are several expensive techniques available in developed countries. Though in developing countries (for instance, India), adsorption technique which is less expensive and economically feasible is used. It has been selected for the present study using some cheap cost chemicals as an effective adsorbent. Therefore the objective of the present work is to test the ability of an Aqua Silencer in removing air pollutants and reduce noise of emission from engine.

IV. SCOPE OF THE PROJECT

An aqua silencer system is designed in such a way as to substitute for conventional single unit engine silencers installed on industrial engines and heavy vehicles. Its construction is simple and it has a slender design; in addition to having a minimal 'footprint', it also optimizes the engine exhaust system for reducing backpressure and decreasing noise levels. It is used to control the noise and emission in IC engines. The reason why we opt for aqua silencer is that, in our world, air pollution causes physically and mentally

harmful effects to human beings and also to the environment. The main contribution of air pollution comes from automobiles and industrial engines releasing gases like carbon dioxide and unburnt Hydrocarbons [6]. By using water as a medium, the sound produced can be lowered. With further development, it can also be used in automobiles.

V. PROJECT METHODOLOGY

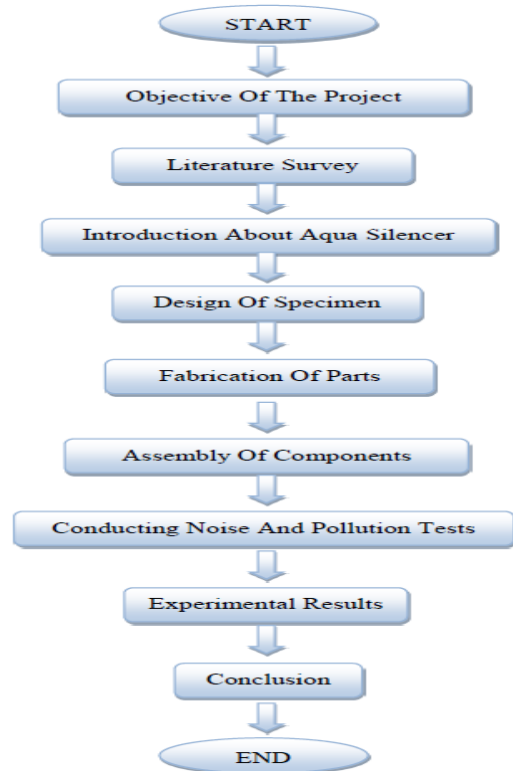


Fig 1: Project methodology

Methodology is a very important element to be considered to make sure the fluent working of the project and to get expected results. In other words, methodology can be described as a framework which contains the elements of the work based on the objectives and scope of the project. A good framework can present the overall view of the project and be used to arrange or extract the data easily. This includes the various steps involved such as literature study, design of specimen, fabrication of parts, assembly, testing phase, etc.

VI. WORK DONE

A. Design of Equipment and Drawing

1.) General Machine Specifications:

The fabrication of aqua silencer requires the following components to ensure the proper and complete operation of the device.

1. Exhaust gas from engine
2. Activated Charcoal layer
3. Outer shell
4. Lime water
5. Perforated tube
6. U tube

7. Drawing for Fabrication Of Aqua Silencer

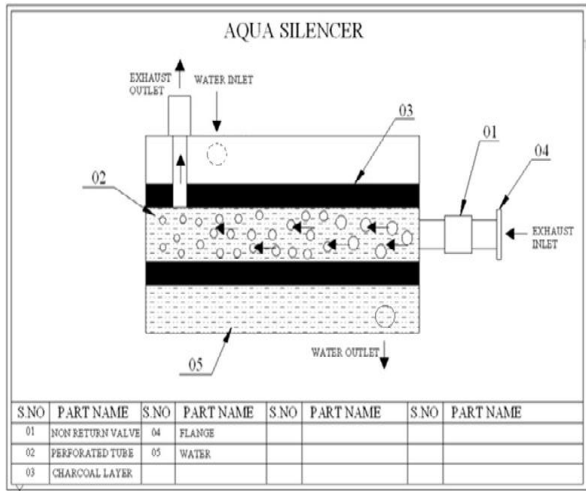


Fig 2: General Design

2.) Part Drawings:

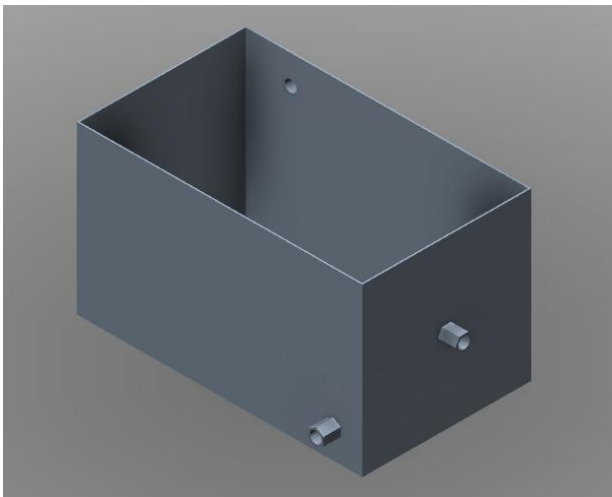


Fig 3: Body of aqua silencer

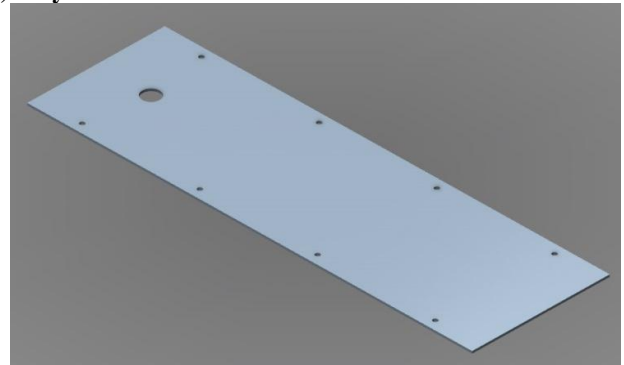


Fig 5: Inner box lid

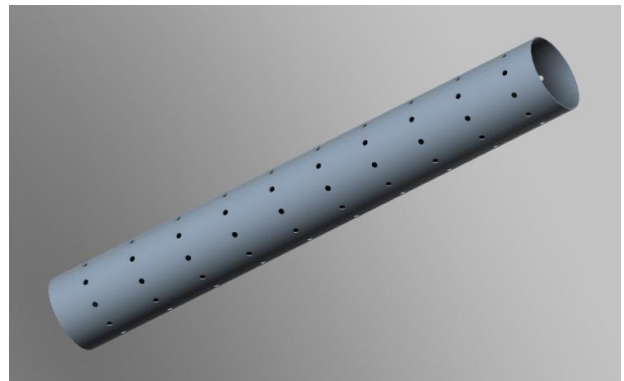


Fig 6: Perforated tube

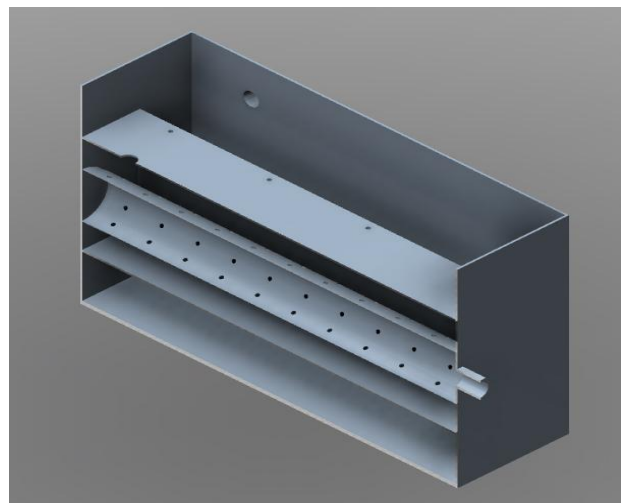


Fig 7: Assembly sectional view

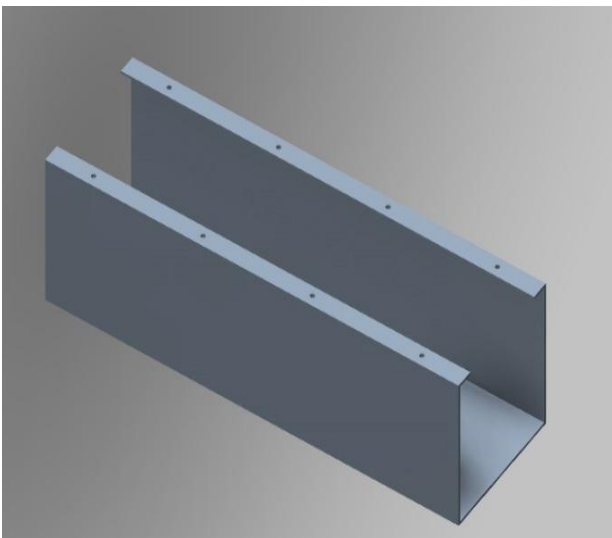


Fig 4: Inner box

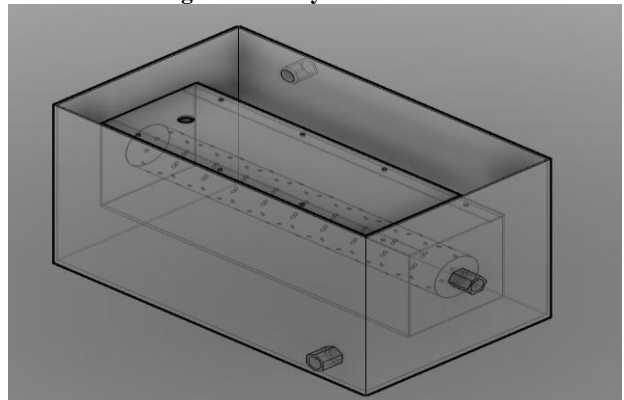


Fig 8: Assembly x ray view

B. Selection Of Material

1.) Factors Determining The Choice Of Materials:

The various factors which determine the choice of material are discussed below.

Properties:

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability etc.

The following types of principle properties of materials can affect material selection

1. Physical
2. Mechanical
3. From manufacturing point of view
4. Chemical

The various physical properties considered are melting point, thermal Conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, magnetic purposes etc.

The various mechanical properties taken under consideration are strength in tensile, Compressive shear, bending, torsional and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, modulus of elasticity, hardness, wear resistance and sliding properties.

The various properties considered from the manufacturing point of view are,

- 1) Cast ability
- 2) Weld ability
- 3) Surface properties
- 4) Shrinkage
- 5) Drawing properties, etc.

Cost:

The cost of material plays an important role in material selection and should be considered carefully. Most often, factors like scrap utilization, appearance, etc are also involved in material selection.

Quality Required:

This generally affects the process of manufacturing and finally the material and the resultant product.

Space Consideration:

Sometimes, materials of different properties have to be selected because the forces in play are high and there are limitations in terms of space.

Availability of Material:

Some materials may be scarce or in short supply. Then the designer may have to opt the use of some other material which may not be a suitable substitute for the designed material.

D. Construction and Working Principle

1.) Construction:

An Aqua Silencer basically consists of a perforated tube which is installed at the exit of the exhaust from the engine, which may have holes of variable diameters. This is done to divide the gas molecules of large proportions to form gas molecules of smaller diameter. Theoretically, four or more sets of holes are made on the perforated tube by drilling. The opposite end of the tube is sealed by a plug. Lime water is

stored inside the perforated tube, which chemically reacts with the exhaust coming from the engine. A small coating of activated charcoal is provided all around the perforated tube using an inner box which holds the charcoal in place and separates the charcoal and lime water from the water in the Aqua Silencer. This unit is then placed in a container in which water is filled to a certain level. A small opening is provided on the lid of the inner box which carries the exhaust from it to the outside using a small diameter pipe. A U-bend of pipe is constructed at the end of perforated tube which doubles as a non-return valve which prevents the back flow of engine exhaust or lime water back into the engine.

2.) Working:

When the exhaust from engine enters the Aqua Silencer, gas molecules of large proportions are converted into gas molecules of smaller diameter using the perforated tube and then they chemically react with the lime water solution and ultimately passes through the charcoal layer, which again purifies the exhaust gases. The activated charcoal is highly porous and has a quite high absorption capacity due to possession of extra free valences in it.

Since the inner box containing the charcoal layer is immersed in water, noise produced is damped and reduced to a low level. Hence, the Aqua Silencer reduces noise and air pollution to an acceptable level.

C. Experimental Setup

Engine Specifications

- | | |
|--------------------|--------------|
| 1. Engine | : Kirloskar |
| 2. Fuel | : H.S.Diesel |
| 3. B.H.P | : 12 KW |
| 4. RPM | : 1500 |
| 5. Lubricating Oil | : SAE 30 |



Fig 9: Experimental Set Up

Outlet of the generator is connected to the inlet of the aqua silencer by using CPVC pipe.

F. Testing

Hatridge Smoke Tester:

Hatridge smoke tester is used to conduct the smoke tests. Hatridge smoke tester is used to test Diesel Exhaust. Smoke meters, also referred to as opacity meters, detect and measure the amount of light blocked in a sample of smoke emitted by

diesel engines. The smoke meter readout displays the smoke density giving a measure of the efficiency of combustion. This makes the smoke meter an excellent diagnostic tool to ensure proper maintenance of diesel engines for improved fuel economy and protection of the environment.

Opacity (N) - The percentage (%) of light transmitted from a source which is prevented from reaching a light detector. (Also known as HSU - Hatridge Smoke Units)

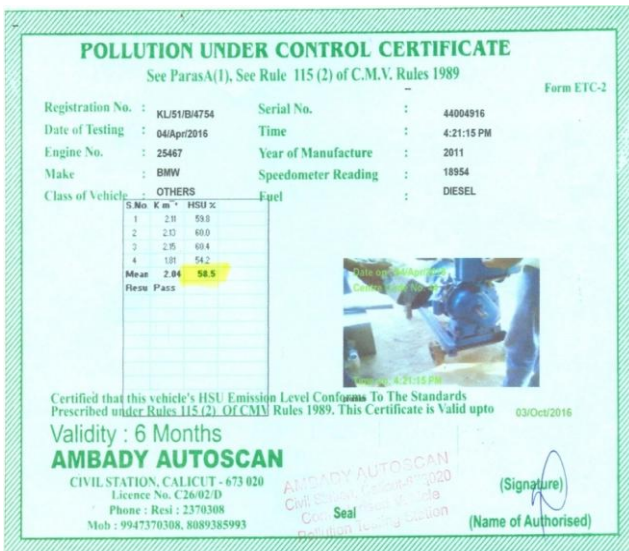
Smoke Density (Km-1) - (also known as "Light Extinction Coefficient" and "Light Absorption Coefficient") A fundamental means of quantifying the ability of a smoke plume or smoke containing gas sample to obscure light. By convention, smoke density is expressed on a per meter basis (m-1). The smoke density is a function of the number of smoke particles per unit gas volume, the size distribution of the smoke particles, and the light absorption and scattering properties of the particles. In the absence of blue or white smoke, the size distribution and the light absorption/scattering properties are similar for all diesel exhaust gas samples and the smoke density is primarily a function of the smoke particle density.

VII. RESULT AND DISCUSSION

A. Testing Case:

1.) Test Using Simple Silencer:

Hatridge smoke tester is directly connected to the outlet of the generator. The amount of HSU and light absorption coefficient is determined. The observed mean HSU value for using simple silencer is 58.5% and the mean light absorption coefficient is $2.04m^{-1}$.



POLLUTION UNDER CONTROL CERTIFICATE
See Paras(A1), See Rule 115 (2) of C.M.V. Rules 1989 Form ETC-2

Registration No. : KLJ51BI4754 Serial No. : 44004916
Date of Testing : 04/Apr/2016 Time : 4:21:15 PM
Engine No. : 25467 Year of Manufacture : 2011
Make : BMW Speedometer Reading : 18954
Class of Vehicle : OTHERS Fuel : DIESEL

S.No.	K m ⁻¹	HSU %
1	2.11	59.6
2	2.10	60.0
3	2.18	60.4
4	1.81	54.2
Mean	2.04	58.5

Resu Pass

Certified that this vehicle's HSU Emission Level Conforms To The Standards Prescribed under Rules 115 (2) Of C.M.V/ Rules 1989. This Certificate is Valid upto 03/Oct/2016

Validity : 6 Months
AMBADY AUTOSCAN
CIVIL STATION, CALICUT - 673 020
Licence No. C26/02/D
Phone : Resi : 2370308
Mob : 9947370308, 8089385993

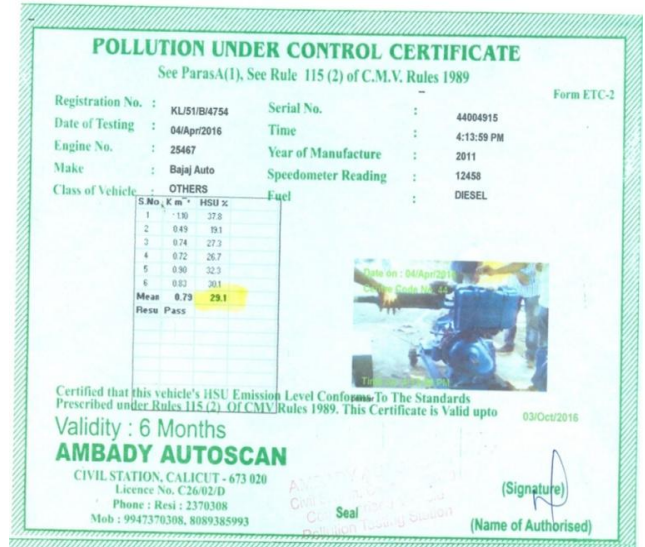
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Fig 10: Pollution certificate for Test Using Simple Silencer

2.) Test Using Aqua Silencer With Activated Charcoal:

Activated charcoal is used in the silencer because of its high absorption capability. Activated charcoal is placed inside the Perforated Tube. It can absorb some of the toxic gases present in the exhaust. The observed mean HSU value

for using simple silencer is 29.1% and the mean light absorption coefficient is $0.79m^{-1}$. The amount of HSU is decreased in this case with respect to test with simple silencer.



POLLUTION UNDER CONTROL CERTIFICATE
See Paras(A1), See Rule 115 (2) of C.M.V. Rules 1989 Form ETC-2

Registration No. : KLJ51BI4754 Serial No. : 44004915
Date of Testing : 04/Apr/2016 Time : 4:13:59 PM
Engine No. : 25467 Year of Manufacture : 2011
Make : Bajaj Auto Speedometer Reading : 12458
Class of Vehicle : OTHERS Fuel : DIESEL

S.No.	K m ⁻¹	HSU %
1	1.30	37.8
2	0.49	19.1
3	0.74	27.3
4	0.72	26.7
5	0.80	32.3
6	0.83	30.1
Mean	0.79	29.1

Resu Pass

Certified that this vehicle's HSU Emission Level Conforms To The Standards Prescribed under Rules 115 (2) Of C.M.V/ Rules 1989. This Certificate is Valid upto 03/Oct/2016

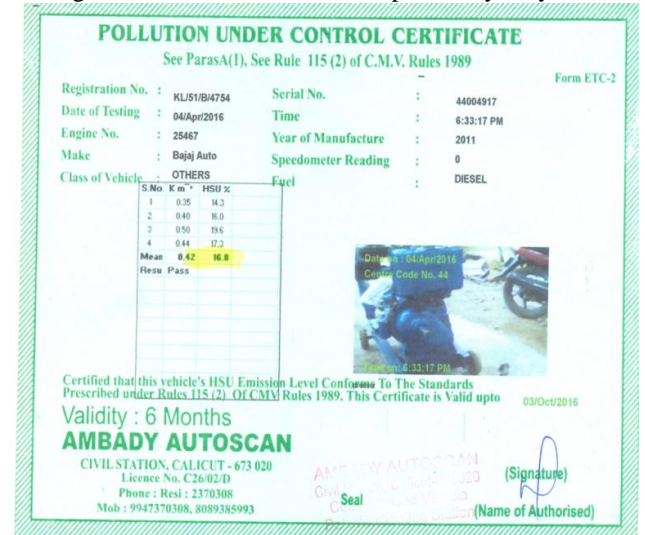
Validity : 6 Months
AMBADY AUTOSCAN
CIVIL STATION, CALICUT - 673 020
Licence No. C26/02/D
Phone : Resi : 2370308
Mob : 9947370308, 8089385993

(Signature)
(Name of Authorised)

Fig 11: Pollution certificate for Test Using Aqua Silencer with Activated Charcoal

3.) Test Using Aqua Silencer with Activated Charcoal and Lime Water:

Perforated tube contains lime water inside it which chemically reacts with exhaust gas from the engine. It absorbs a large amount of the toxic gases present in the exhaust. The observed mean HSU value for using simple silencer is 16.8% and the mean light absorption coefficient is $0.42.m^{-1}$. Percentage of HSU and k value is comparatively very low.



POLLUTION UNDER CONTROL CERTIFICATE
See Paras(A1), See Rule 115 (2) of C.M.V. Rules 1989 Form ETC-2

Registration No. : KLJ51BI4754 Serial No. : 44004917
Date of Testing : 04/Apr/2016 Time : 6:33:17 PM
Engine No. : 25467 Year of Manufacture : 2011
Make : Bajaj Auto Speedometer Reading : 0
Class of Vehicle : OTHERS Fuel : DIESEL

S.No.	K m ⁻¹	HSU %
1	0.35	16.2
2	0.40	16.0
3	0.50	19.6
4	0.44	17.3
Mean	0.42	16.8

Resu Pass

Certified that this vehicle's HSU Emission Level Conforms To The Standards Prescribed under Rules 115 (2) Of C.M.V/ Rules 1989. This Certificate is Valid upto 03/Oct/2016

Validity : 6 Months
AMBADY AUTOSCAN
CIVIL STATION, CALICUT - 673 020
Licence No. C26/02/D
Phone : Resi : 2370308
Mob : 9947370308, 8089385993

(Signature)
(Name of Authorised)

Fig 12: Pollution certificate for Test Using Aqua Silencer with Activated Charcoal and Lime Water

4.) Noise Test:

Noise test is conducted by using sound level meter. The electrical signal from the transducer is fed to the pre-amplifier of the sound level meter and if needed, a weighted filter over a specified range of frequencies. Further amplification prepares the signal either for output for rectification or to other

instruments such as a tape recorder and direct reading on the meter.

The rectifier gives the RMS value of the signal. The RMS signal is then exponentially averaged using a time constant of 0.1 s ("FAST") or 1 s ("SLOW") and the result is displayed digitally or on an analog meter.

In some cases, the sound level meter does not include a logarithmic converter. The scale on the indicating device is then exponential so that the linear signal may be read in dB. In this case, the dynamic range of the display is usually restricted to 10 to 16 dB and the precision of the reading is rather poor. In the case of intermittent noise, the user must constantly adjust the amplifier to adapt the output signal to the dynamic range of the display.

When a log converter is used, the display scale is linear in dB and its dynamic range is usually much greater. This type of display has the advantage of providing the same precision at any level and permitting a much better appreciation of the range of fluctuations of the noise to be measured. In this regard, digital displays are less useful.



Fig 13: Sound level meter

The measured value of sound using sound level meter for our aqua silencer is shown in table 1

Case 1: Using simple silencer

Case 2: Using silencer with activated charcoal

Case 3: Using silencer with activated charcoal and lime water

Sl. No	Noise Level (dB): Case 1	Noise Level (dB): Case 2	Noise Level Reduction in Case 2 w.r.t Case 1 (%)	Noise Level (dB): Case 3	Noise Level Reduction in Case 3 w.r.t Case 1 (%)
1	104.5	88	15.78	85	18.66
2	103	87.8	14.7	85.4	17.08
3	105	89	15.24	86.1	18

Table 1: Noise Level Comparison

5.) Comparison:

The comparison of Smoke Density Comparison, light absorption and sound testing for the above three cases like engine using Simple Silencer, Using Aqua Silencer With Activated Charcoal and Using Aqua Silencer With Activated

Charcoal and Lime water are shown in the graphs given below.

- Case 1: Test using simple silencer
- Case 2: Test using silencer with activated charcoal
- Case 3: Test using silencer with activated charcoal and lime water

Smoke Density Comparison

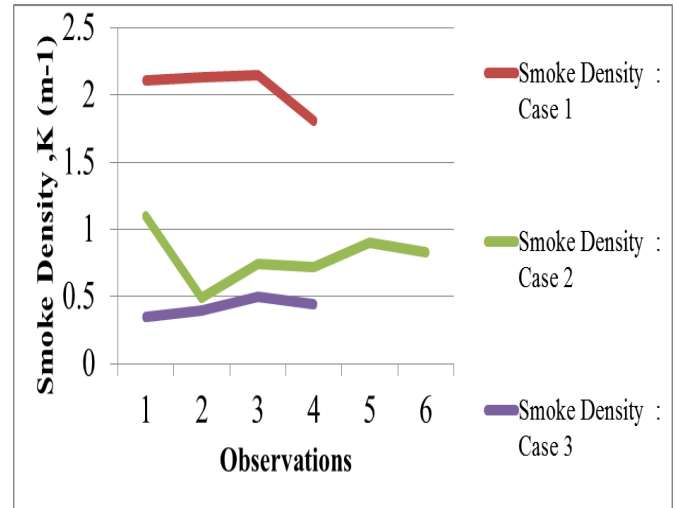


Fig 14: Comparison of Smoke Density Levels

This graph shows the smoke density comparison in 3 different cases. From this graphs it is seen that the smoke density is dramatically reduced while using an Aqua Silencer with Activated Charcoal and Lime water than the above two cases.

Smoke Opacity Comparison

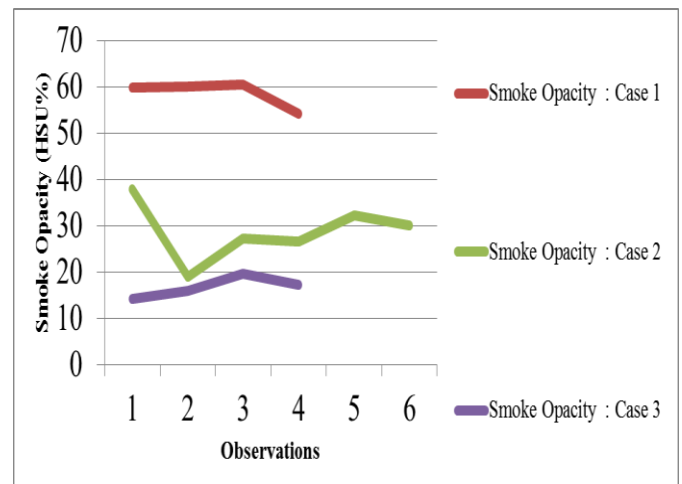


Fig 15: Comparison of Smoke Opacity Levels

This graph shows the Smoke Opacity Comparison in 3 different cases. From this graphs it is seen that the Smoke Opacity is dramatically reduced when using Aqua Silencer with Activated Charcoal and Lime water than the above two cases.

Noise Level Comparison

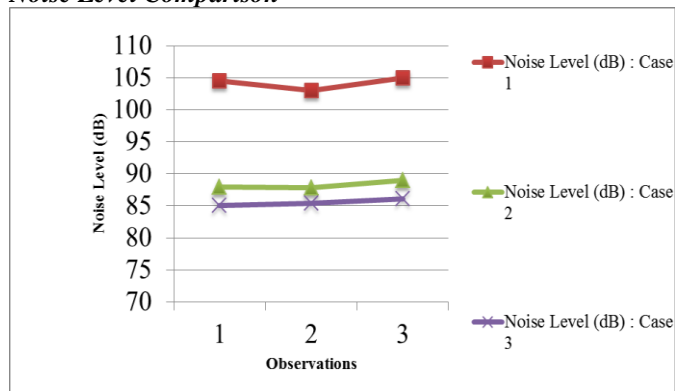


Fig 16: Comparison of Noise Levels

This graph depicts the noise levels in 3 different cases. From this graph, it is observed that the noise is dramatically reduced when using Aqua Silencer with Activated Charcoal and Lime water than the above two cases.

VIII. FUTURE ENHANCEMENT

There has understandably been an increasing concern in recent years over the increasing rate of transportation and discharge of industrial waste waters into environment as well as the release of toxic emission into the atmosphere from automobile and industrial engines. Technological breakthroughs like the AquaSilencer can be the answer to the reduction of toxic emissions into the environment from engines. Currently, the AquaSilencer is only suitable for use in industrial engines and heavy weight vehicles. But R&D departments have taken the subject into consideration and are going into developing and redesigning the AquaSilencer to make it possible to be fitted in to automobiles keeping its aerodynamic properties stable and sustaining or increasing its efficiency.

IX. CONCLUSION

It has been experimentally observed that the aqua silencer is successfully effective in reducing emission of gases from the engine exhaust. By using water as a medium, the sound levels have been reduced and by using activated charcoal in water, it produces almost pollution-free and smokeless emission and is also cheap considering long term use. The aqua silencer’s performance is almost equivalent to the conventional silencer. It can be widely used in industrial engines and with a little improvisation, in heavy weight vehicles. This project analyzed the smoke content of the exhaust gas before and after treatment and it was found that there is a considerable reduction in the emission as pointed out by the test results.

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