

Statistical Analysis and Testing of Aqua Silencer through Experimental Set up of Diesel Engine



#¹Shubham Ghule, #²Kiran Supekar, #³M. M. Kulkarni

¹shubhamghule24@gmail.com

²kiran150996@gmail.com

³mohan.kulkarni@sinhgad.edu

#¹²Student, Department of Mechanical Engineering,

#³Asst. Prof., Department of Mechanical Engineering,

NBN Sinhgad School of Engineering, Pune, Maharashtra, India.

ABSTRACT

Purity of air is most important from the public health point of view, because every individual person breathes approximately 22000 times per day, inhaling about 15 to 22 Kg of air daily. Polluted air causes physical ill effect decides undesirable aesthetic and physiological effects. Air pollution can be defined as addition to our atmosphere of any material, which will have a deleterious effect on life upon our planet. The main pollutants contribute by automobiles are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOx) and Lead. Automobiles are not only source of air pollution, other sources such as electric power generating stations, industrial and domestic fuel consumption, refuse burning, industrial processing etc. also contribute heavily to contamination of our environment so it is imperative that serious attempts should be made to conserve earth's environment from degradation. A twin filter silencer is an attempt in this direction; it is mainly dealing with control of emission and noise. An aqua silencer is fitted to the exhaust pipe of engine. Sound produced under water is less hear able than it produced in atmosphere. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. Because of this property, water is used in this and hence its name as "Aqua Silencer". Due to this we reduce the noise and emissions from the exhaust.

Keywords- Aqua Silencer; Unburned Hydrocarbon; Air Pollution; Carbon Monoxide; Water Molecules.

ARTICLE INFO

Article History

Received: 3rd May 2017

Received in revised form :

3rd May 2017

Accepted: 8th May 2017

Published online :

8th May 2017

I. INTRODUCTION

Air pollution in the world has emerged as the focus of environmental remediation efforts because of their toxicity and threat to human beings. Due to rapid growth of industrialization and urbanization with new technological advancements, the existing environments are contaminated by emission from automobile and industries containing organics, color, heavy metal etc. The environment contamination particularly by air pollutants from industrial effects and their persistence in food chain has been of major concern as it is posing a serious threat to environment including fisheries.

Also diesel 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, 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, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. Hence the removal of toxic air pollutant contaminants from atmosphere is one of the most important environmental and economic issues today.

In the silencer, the Charcoal and Water so it is called hybrid aqua silencer, and it is useful in automobile, industry, DG sets & DG machines, Marin and Boats also so, It is known as hybrid universal aqua silencer.

Problem Statement:

Considering the available fuel resources and the present technological development, Diesel fuel is evidently indispensable. We cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. This project is an attempt

to reduce the toxic content of diesel exhaust, before it is emitted to the atmosphere.

Objective :

- 1 To design equipment that reduces harmful gases (Toxic Content) from exhaust of an engine.
- 2 To fabricate the Aqua Silencer.
- 3 To reduce gases and particulate in engine emission.
- 4 Test the ability of some chemicals in removing air pollutants from automobile emission.

Scope :

There has been an increasing concern in recent years over increasing transportation and discharge of industrial waste water in environment. The automobile emissions contain air pollutants and other species. Almost all pollutants are toxic in nature. Some of the examples are CO, CO₂, NO_x and other hydrocarbons. Among the air pollutants, all are effective pollutants. Hence, removal of pollutants was selected for the present study. Several expensive techniques are available in developed countries. But in developing countries like India, this technique is less expensive and economically feasible, is selected for present study using some cheap cost chemicals. There are some other techniques like absorption method using effective absorbent are also developing.

II. EXPERIMENTAL SETUP

The principle of aqua silencer is by bubbling the exhaust gas through the scrubber tank containing an alkaline solution, here the temperature of the gases is reduced, while most of the oxides of nitrogen in the exhaust are rendered non – toxic.

These sampling points enable us to measure the exhaust gas content before and after scrubbing. The difference is evaluated and effective control is initiated. The samples are analyzed by using an orsat apparatus or exhaust gas analyser.

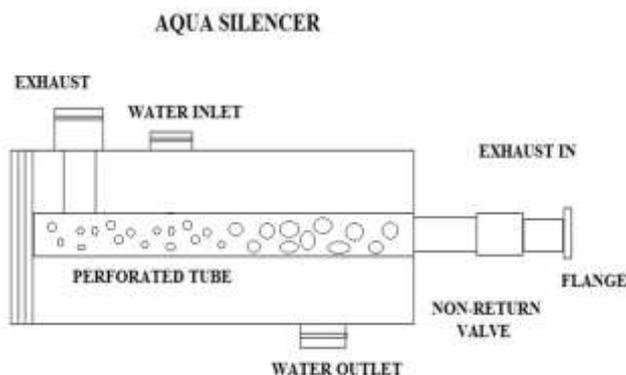


Fig 2.1: Schematic Representation of Aqua Silencer

Constructional Features

Basically an aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube may have holes of different diameters. The very purpose of providing different diameter hole is

to break up gas mass to form smaller gas bubbles the perforated tube of different diameter. Generally 4 sets of holes are drilled on the perforated tube. The other end of the perforated tube is closed by plug.

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. 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. The scrubber tank is fabricated in three stages and it contains the following sub-assemblies.

1. Tank.

2. Bell – Mouth.

3. Lime stone container

4. Level plug – Drain Assembly.

The tank is made of standard steel plates of 3mm thickness of quality structural steel conforming to BIS: 226, Designation ST 42S. The tank is fabricated using Electric Arc welding or Gas welding processes to withstand a maximum pressure of 0.8N/mm² [8Kg/Cm²], with leak – proof.

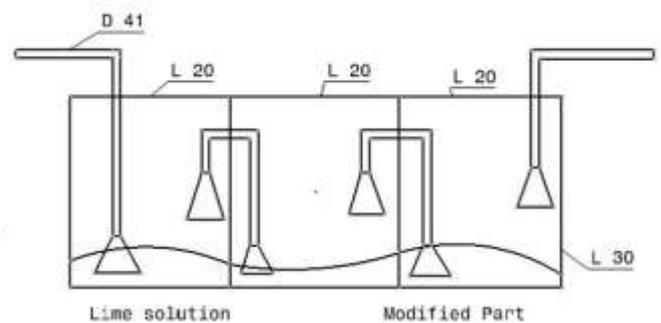


Fig 2.2: Construction of Aqua Silencer

III. DESIGN CONSIDERATIONS

The design of exhaust gas manifold is very important in case of high speed diesel engines. In order to maintain the exhaust gas pressure within the required limits, the exhaust gas manifold is designed so that, the gases, which come out of the cylinder flows very smoothly, before it is let out into the atmosphere. This is absolutely essential in order to maintain the back pressure within safe limits, so that the engine can be kept at the optimum operating level. The back pressure, if it is allowed to exceed the pre-determined level, the effort on the part of the piston for scavenge is considerably increased and so power is lost in performing the above, so, the primary consideration when introducing any modification in exhaust system does not and shall not increase the back pressure which drastically affect the performance characteristics of an engine. To be more precise, the speed of the engine is affected for a

given specific fuel consumption rate and so the combustion characteristics of an engine are all affected. As a net result of the combustion is not proper and complete which results in the increased impurities or unburnt gases. This principle against the purpose of introducing any system whose sole object is reducing the very toxic property of the exhaust gas. So, it is implied that the introduction of any system reduces the toxic property of the exhaust gas, shall not result in any effects in the opposite direction. So by introducing any component in the system the flow path length and the resistance to flow are indirectly increased. So the increase of back pressure is inevitable unless the increase in magnitude compensated in the design of the component itself. The exhaust gas has to pass through the water, which is filled in the scrubber tank. In any case, the outlet from the engine shall be kept below the water level in the scrubber tank for that the gas will pass through the water. The gas has no to push the water, in order to bubble through the water. The gas has to push the water, in order to bubble through the water in the scrubber tank. This may create chances to increase the backpressure. The baffles, which are provided to deflect the exhaust gases, also offer resistance to the flow and in turn increase the back, pressure. Due to the high temperature, the exhaust gas is let out from the engine, some of the water particles which come in contact, readily changes its phase from liquid state to gaseous state i.e., Steam Which increases the net mass of the exhaust gas flow per unit time. The resultant may increase the backpressure.

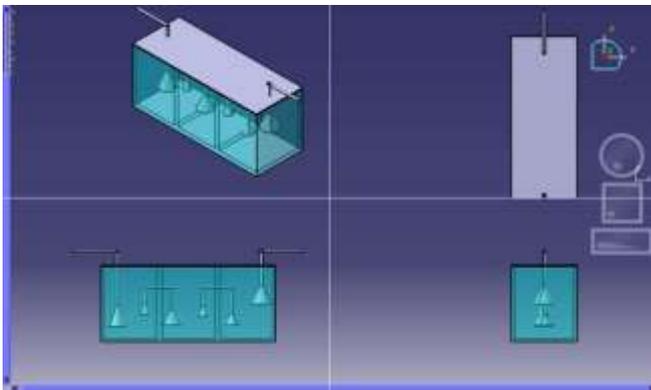


Fig 3.1: 3D Views of Aqua Silencer

IV. WORKING OF AQUA SILENCER

The problems that arise from the Diesel utilization in inflammable environment may be listed as follows:

- Gases and particulate in engine emission.
- Heat and Humidity.
- Risk of explosion and fires.
- Transportation and storage of fuel.
- High speed in long hauls.
- The Risk of trackless vehicles entering inadequately ventilated areas.
- Noise.

In addition to heat and water vapor, the pollutants in diesel 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 high temperature high pollutant exhaust gas is allowed to pass through the belt – mouth assembly of the scrubber in the first phase. The bell – mouth of the inlet/outlet is approximately 2 ½ times more in an area is that of the inlet. This allows the exhaust gas to expand considerably. This expansion allows the gas to cool, because the temperature is a function of pressure. This considerable reduction of backpressure allows for the additional involved due to the introduction of water and lime stone container.

In the scrubber tank water is used as an alkaline solution mainly to dissolve the Unburned Hydro Carbons (UBHC). By this method, the UBHC, even if it is in glowing conditions, it is dissolved in water; thereby it is suppressing a spark which could escape from the engine to the inflammable environment.

Chemical 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.
 $NO_2 + 2H_2O = 2HNO_2 + 2HNO_3$ (Diluted).....I

Chemical Reaction 2

If a small amount of limewater is added to scrubber tank, further reaction takes place as below.
 $Ca(OH)_2 + 2HNO_3 = Ca(NO_3)_2 + 2H_2O$
 $Ca(OH)_2 + 2HNO_2 = Ca(NO_2)_2 + 2H_2O$II

Chemical Reaction 3

When the carbon-di-oxide present in the exhaust gas comes in contact with the limewater, calcium carbonate will precipitate. The calcium carbonate when further exposed to carbon-di-oxide, calcium-bi-carbonate will be precipitated. The following is the chemical reaction,
 $Ca(OH) + CO_2 = CaCO_3 + H_2O$
 $CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2$III

Chemical Reaction 4

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. The following equation gives the chemical reaction and calcium sulphite will precipitate.
 $Ca(OH)_2 + SO_2 = CaSO_3 + H_2O$IV

Chemical Reaction 5

$CaCO_3 + SO_2 + H_2O = CaSO_3 + CO_2 + H_2O$... V

From calcium carbonate, calcium sulphite will precipitate and CO₂ will be 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.

V. EFFECTS OF DISSOLVED GASES ON LIME WATER

The lime water is a good absorbing medium. In aqua silencer the gases are made to be dissolved in lime water. When 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 fol rotten egg smell, acidify and corrosion of metals.

Action of dissolved CO₂

The dissolved carbon dioxide forms bicarbonate at lower PH and Carbonates at higher PH. This levels 40-400 mg/liter.. The carbon dioxide mixes with water to form Carbonic acid. It is corrosive to metals and causes greenhouse effect.

Effect of dissolved NO_x

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

Adsorbition Process

Activated charcoal is available in granular or powdered form. As it is highly porous and Possess free valences. So it possess high absorption capacity. Activated carbon is more widely used for the removal of taste and odorous from the public water supplies because it has excellent properties of attracting 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. But it is always added before filtration. Feeding devices are similar to those used in feeding the coagulants.

VI. EXHAUST GAS ANALYSIS

Emissions from diesel engines can be classified in same categories as those from the gasoline engines but the level of emission in these categories varies considerably. A sample of diesel exhaust may be free from smoke, odorless, and have no unburned hydrocarbons (UBHC) or it may be heavily smoke laden, highly mal-odorous and can have heavy concentration of UBHC. It shows the approximately the possible variations in concentration of different constituents of diesel exhaust. The concentration is deceptively low in diesel engines, as compared to petrol engines. However, as the specific air consumption in diesel engines is always high due to excess air, the total amount of pollutants is nearly same in diesel and petrol engine exhaust. Hence, diesel exhaust emissions are as great concern as of petrol engines. Engine type and the

mode of operation are two main factors, which influence the exhaust emissions from a diesel engine. Table 4.1 represents the Range of concentration of different constituents of diesel exhaust.

Table5.1: Range of concentration of different constituents of diesel exhaust

Sr. No.	Constituent	Minimum	Maximum
1	Hydrocarbon,(HC)	50 ppm	1000 ppm
2	NO _x	100 ppm	2000 ppm
3	CO	Zero	2 percent

Sr. No.	Constituent	Minimum	Maximum
4	RCD	15	100
5	UBHC	10	50

Exhaust smoke

Smoke, which is defined as visible products of combustion, is due to poor combustion. It originates early in the combustion cycle in a localized volume of rich fuel – air mixture. Any volume in which fuel is burned at relative fuel – air ratio greater than 1.5 and at pressure developed in diesel engines products soot. The amount soot formed depends upon local fuel – air ratio, type of fuel and pressure. If this soot, once formed finds sufficient oxygen it will burn completely. If, it is not burned in combustion cycle it will pass in the exhaust, and if insufficient quantity, will become visible. The size of the soot particles affects the appearance of smoke. The soot particles, which are chain – line clumps of carbon, agglomerate into bigger particles, which have an objectionable darkening effect or diesel exhaust.

The smoke of a diesel engine is, in general, two basic types

- Blue – white smoke,
- Black smoke.

CAUSES OF SMOKE

As mentioned earlier the cause of the smoke is incomplete burning 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

VII. RESULTS

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

Case 1: Using simple silencer

Case 2: Using silencer with activated charcoal

Case 3: Using silencer with activated charcoal and lime water

Table 7.1 : Noise Level Comparison

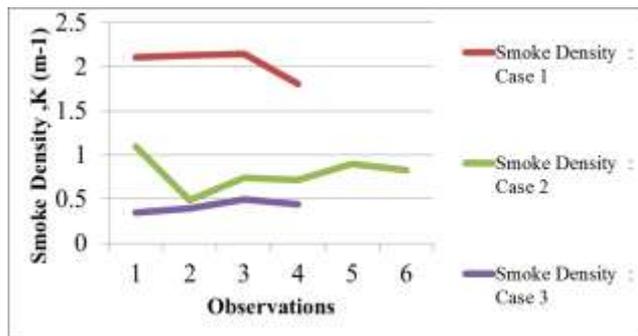
Sl. No	Noise Level (dB) : Case 1	Noise Level (dB) : Case 2	Noise Level Case2 w.r.t Case1 (%)	Reduction in Noise Level (dB) : Case 3	Noise Level Reduction in Case3 w.r.t Case1 (%)
1	104.5	88	15.78	85	18.66
2	103	87.8	14.7	85.4	17.08
3	105	89	15.24	86.1	18

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

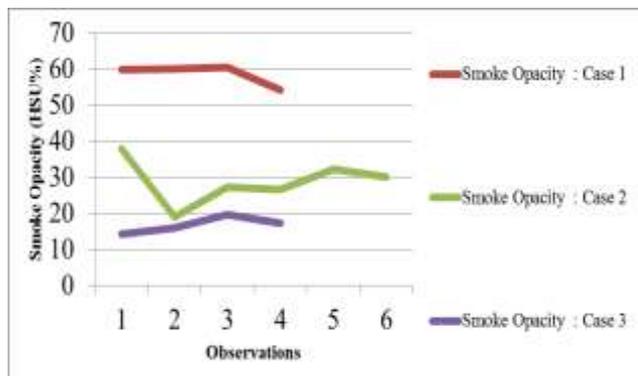
Case 2: Test using silencer with activated charcoal

Case 3: Test using silencer with activated charcoal and lime water



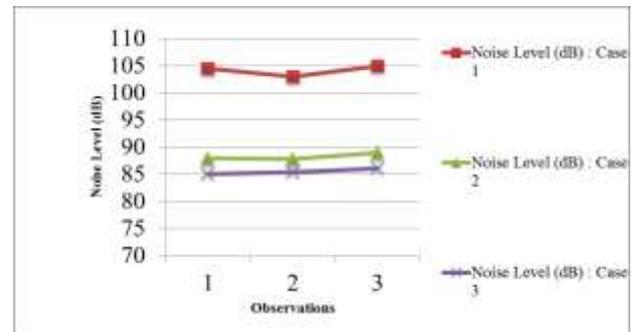
Comparison of Smoke Density Levels

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.



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



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.

Merits

- No vibration when the engine is running.
- Start the engine easy.
- Control emission and noise in greater level.
- Carbon is precipitated.
- Efficiency is higher as compared to charcoal layer method.

Demerits

- Lime water filling is required once in a year
- Silencer weight is more comparing to conventional silencer.
- Additional space is required.

VIII. CONCLUSION

1. Water in the scrubber tank can itself play an important role in absorbing the obnoxious products of combustion like the oxides of Nitrogen.
2. It also serves to dissolve the unburned hydrocarbon, which is present in the Diesel emission, thereby serves to suppress a spark before it is emitted to the surrounding environment.
3. In place of water, a weak lime solution could be used and this change will allow for the chemical reaction to take place at a faster pace.
4. All the gases present in the Diesel Exhaust except the Carbon Monoxide is readily with the working media namely the limewater and Calcium Carbonate.
5. Water, intern indirectly supports the chemical reaction by not allowing the unburned Hydro Carbons to deposit over the Calcium Carbonate, which will otherwise prevent further Chemical reaction, between the working media and constituents of the Diesel emission.

IX. ACKNOWLEDGMENT

It is indeed a great pleasure and moment of immense satisfaction for we to present a project report on "Statistical Analysis and Testing of Aqua Silencer through Experimental Set up of Diesel Engine" amongst a wide panorama that provided us inspiring guidance and encouragement, we take the opportunity to thanks to thanks those who gave us their indebted assistance.

We wish to extend our cordial gratitude with profound thanks to our internal guide Prof. M. M. Kulkarni for his everlasting guidance. It was his inspiration and encouragement which helped us in completing our project.

Our sincere thanks and deep gratitude to Head of Department, Prof. M. M. Joshi and other faculty member; but also to all those individuals involved both directly and indirectly for their help in all aspect of the project.

At last but not least we express our sincere thanks to our Institute's Principal Dr. R. S. Prasad, for providing us infrastructure and technical environment.

Effectively by Using TI Nano tubes in Aqua Silencer", International Journal of Engineering Sciences and Research Technology .

10. Rawale Sudrshan S & Patil S Nehal S, (September 2013) "Use of aqueous Ammonia in Silencer for removal of CO₂, SO₂ and NO_x from exhaust gases of IC Engines", International Journal of Engineering Science and Innovative Technology, Vol.2, Issue 5.
11. Sharad R. Mahajan "Air Pollution from I.C. Engines & its Control" International Journal of Inventive Engineering and Sciences (IJIES), Volume-1, Issue-11, October 2013. Yogesh V Morankar , Prof. M. R. Khodke , "Noise Reduction Of A Diesel Engine: A Review," International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181, Vol. 3 Issue 5, May – 2014.

REFERENCES

1. P.Balashanmugam¹,G.Balasubramanian², "Developments of Emission and Noise Control Device (Aqua Silencer)" IJMTER, Volume 02, Issue 01, [January - 2015]
2. M. M.Kulkarni, S.S.Kore, "Performance Characterization of Single Cylinder DI Diesel Engine blended with Castor Oil and Analysis of Exhaust Gases", IJERT, Volume 1(02), 2012.
3. M. M. Kulkarni, V. S. Dhupal, "Performance Characterization of Single Cylinder DI Diesel Engine blended with Castor Biodiesel", IJERT, Volume 1(02), 2012.
4. Sagar Gite, Aditya Ingole, M.M.Kulkarni "Experimental Investigation and Testing of Diesel Engine and Analysis of Exhaust Gases by using Aqua Silencer", IERJ, Volume 2 Issue 8, page 2496-2500,2017, ISSN 2395-1621.
5. Alen.M.A1 , Akshay.M2, Prem Sankar.R3 , Mohammed Shafeeque.M4 "Fabrication and Testing Of Aqua Silencer", IRJET, Volume 02 Issue 05, Aug-2015
6. keval i. Patel, Mr. swastik r. gajjar, "Design And Development Of Aqua Silencer For Two Stroke Petrol Engine", IJRST, Volume 01, Issue 01, June 2014
7. Aniyani, Akshay AJI, Anandhu Raj , Sharon T.R, Sarath Raji, Ajbin K "Fabrication and Testing of Portable Twin Filter Aqua Silencer",IJMIT, Vol. 3, Issue 2, October 2015 - March 2016,
8. S. M. Kumar, A. Ramesh and B. Nagalingam, "An experimental comparison of methods to use methanol and jatropa oil in a compression ignition engine", Biomass and Bioenergy, Vol. 25, pp. 309-318, 2003.
9. Mankhiar Ajay B, Sindhu L S, G Sasikala, (March 2014) "An Advancement to Reduce Pollution