

# Design and Performance Evaluation of AQUA Silencer

R.Sambasivam <sup>1</sup>, P.Devendran <sup>2</sup>, Gokul <sup>3</sup>, Prasanth <sup>4</sup>, Santhosh kumar <sup>5</sup>, Thirunthaiyan <sup>6</sup>

<sup>1,2</sup> Assistant Professor, Department of Mechatronics Engineering, SNS College of Technology, Tamilnadu – 641035

<sup>3,4,5,6</sup> B.E Mechatronics Engineering Student, Department of Mechatronics Engineering, SNS College of Technology, Tamilnadu – 641035

\*\*\*

**Abstract** - Diesel and petrol are widely used in automobiles, generators. In spite of their high thermal efficiency, one cannot ignore the fact about the effect of their exhaust, in the atmosphere. Due to high cost of petrol, diesel engines are more in use. Anticipating the use of these fuels, even more in the near future; this system developed used to control the toxic gases, coming out of the diesel and petrol engines. These toxic gases are harmful not only to the atmosphere, but also to the human & animal race. Objective of this project is to design & fabricate a simple system, where the toxic levels is controlled through chemical reaction. This system acts itself as a silencer; there is no need to separate the silencer. The whole assembly is fitted in the exhaust pipe; it does not give rise to any complications in assembling it.

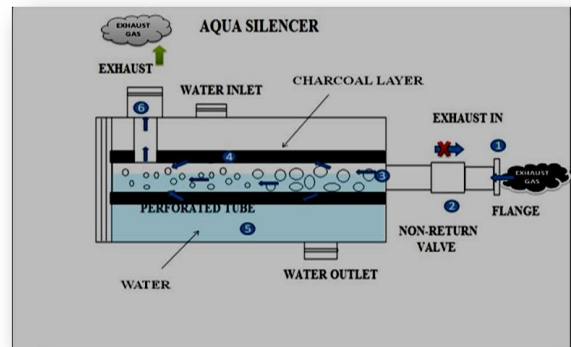


Fig -1: Aqua Silencer Schematic Diagram

**Key Words:** Perforated tube, Lime Water, Baffles, Glass Wool, Aqua Silencer, Non-Return Valve, Charcoal Layer

## 1. INTRODUCTION

Petrol and Diesel are widely used in Internal Combustion engines. Exhaust gas or flue gas emitted because of the combustion of fuels such as natural gas, gasoline, petrol, diesel fuel, coal. The largest part of most combustion gas is nitrogen (N<sub>2</sub>), water vapour (H<sub>2</sub>O) (except with pure-carbon fuels), and carbon dioxide (CO<sub>2</sub>) (except for fuels without carbon); these are not toxic or noxious (although carbon dioxide is a greenhouse gas that contributes to global warming). A relatively small part of combustion gas is undesirable noxious or toxic substances, such as carbon monoxide (CO) from incomplete combustion, hydrocarbons (properly indicated as C<sub>x</sub>H<sub>y</sub>, but typically shown simply as "HC" on emissions-test slips) from un-burnt fuel, nitrogen oxides (NO<sub>x</sub>) from excessive combustion temperatures, and particulate matter (mostly soot). This toxic substances pollutes the environment, causes ill effects to human beings. Therefore, we have planned to fabricate Aqua-silencer and test it in internal combustion engine-exhaust system. This Aqua-silencer removes dust, toxic gases and reduces temperature, Noise

## 2. DESIGN & MODELLING

The model design was carried out based on the selection of engines and the materials requirements. The model has designed on solid works BS2013 based on the following dimensions:

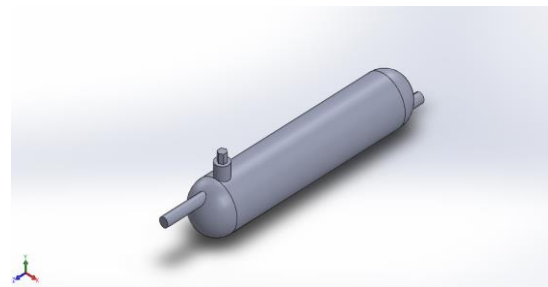


Fig -2: Model of Aqua Silencer

The design of the perforated tube is designed based the silencer of an two wheeler chosen in solid works

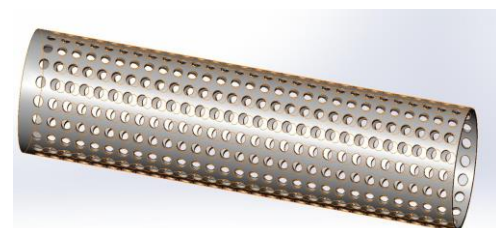


Fig -3: Model of perforated tube

The final sectional view of a designed perforated tube explained in terms of an orthographical projection. The designed is successfully generated and analyzed with an ease to get an accurate results.

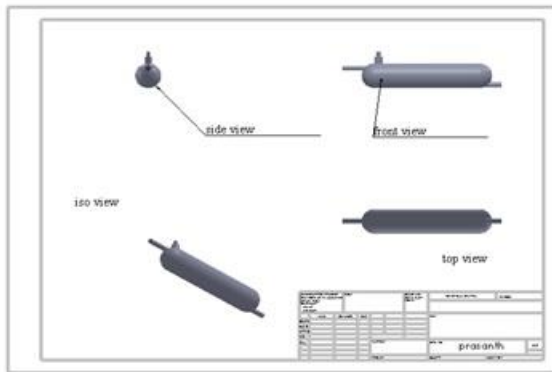


Fig -4: Sectional view

INPUT PARAMETERS	
Inlet Tube	1inch diameter and 1mm thick Mild Steel.
Outlet Tube	2 ½ inch diameter and 1.5mm thick Mild Steel.
Perforated Tube	1*1inch square tube, 1 gauge thickness Mild Steel.
Baffles	18 gauge thickness Mild Steel Sheet metal.
Total Box Size	8*8 inch and 18 gauge Mild Steel Sheet metal.
Filter	Glass Wool

Table -1: Input Parameters

### 3. SIMULATION & PARAMETERS

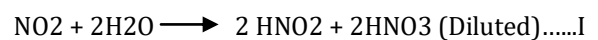
The exhaust gases from the engine come into the pipe in aqua silencer. Finally it reaches perforated tube which comes out from holes and comes into contact with Water or Lime water or oil; (which could be otherwise being any alkaline solution).It forms bubble where the obnoxious products of combustion are scrubbed when bubbled through it. The Effective cooling takes place within the short span of time available for the gas to pass through the oil. The length of bubbling can be increased by the oil level in the scrubber tank. But this will be increased result in an abnormal backpressure, which inadvertently affect the performance of the engine. And for this reason the bell - mouth is a multipurpose component, to allow for reduction in back pressure, and provides for an increased contact area with the scrubbing agent. The baffles are of invaluable help to reduce the carryover of oil particles which are converted into steam, which otherwise will escape out of the system. And the gas passes through glass wool which removes further dust particulates.

### 3.1 DETAILS OF CHEMICAL REACTIONS

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.

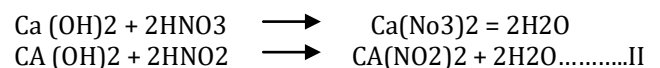
#### 3.1.1 CHEMICAL REACTION 1:

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.



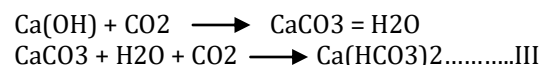
#### 3.1.2 CHEMICAL REACTION 2:

If a small amount of limewater is added to scrubber tank, further reaction takes place as below.



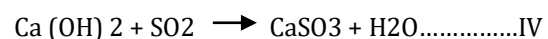
#### 3.1.3 CHEMICAL REACTION 3:

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.3



#### 3.1.4 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.



Because CO is chemically balanced and stable, it will not readily react with water or with any by - products, which is resulted from the above reactions. Also the negligible volume (0.2%) of CO present in the Diesel emission is not such a menace, when compared to the petrol engine exhaust which as high as 10% of CO. Even though, the limewater absorbs a part of the oxides of Nitrogen, carbon-di-oxide, the time limitation for the reaction take place allows a considerable percentage to escape. But, the stone container, which is provided with limestone or calcium carbonate, (CaCO3),

encourages further chemical reaction, in the presence of steam, which evaporates from the scrubber tank due to the high exhaust temperature (400°C - 700°C). The following are the chemical reactions for the oxides of Nitrogen (NO<sub>x</sub>) Carbon-di-oxide (CO<sub>2</sub>) and Sulphur-di-oxide (SO<sub>2</sub>).

### 3.1.5 CHEMICAL REACTION 5:



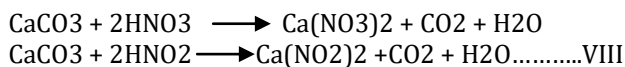
From calcium carbonate, calcium sulphite will precipitate and CO<sub>2</sub> will be by-product. Because of the small percentage and SO<sub>2</sub> presence, the liberation of Carbon dioxide is very less. But the liberated CO<sub>2</sub> will again combine with CaCO<sub>3</sub> to form calcium bicarbonate as mentioned in equation 5.

### 3.1.6 CHEMICAL REACTION 6:

The presence of steam makes it possible to have a preliminary reaction with oxides of nitrogen, in the following manner



The resultant products when come in contact with calcium carbonate the following reaction takes place



i.e., calcium Nitrate Ca(NO<sub>3</sub>)<sub>2</sub> and calcium Nitrite Ca(NO<sub>2</sub>)<sub>2</sub> are the by products, and CO<sub>2</sub> is liberated. The liberated CO<sub>2</sub> again combines with calcium carbonate to form calcium bicarbonate (equation 5).

## 4. TESTING & ANALYSIS

The Testing is carried out under the emission control circumstances where the measurements of the exhaust gas contents were taken and results were carried and analyzed in the following :

### 4.1 REDUCTION OF ABNOXIOUS EXHAUST PARTICULATES

The principle involved is by bubbling the exhaust gas through the scrubber tank containing an water or lime stone or engine oil(2T,4T), here the temperature of the gases are reduced, while most of the oxides of nitrogen in the exhaust are rendered non - toxic. Lime stone water in the scrubber tank reduces the considerable percentage of Sulphur - di - oxide present in the exhaust. The provision of suitable baffles in the scrubber tank aids the turbulence so that, thorough scrubbing take place.

## 4.2 MEASUREMENT OF EXHAUST GAS CONTENT ANALYSIS AND CONTROL

For measuring the contents of the exhaust gas, provisions are made to take samples between engine outlet and scrubber inlet and after the scrubber outlet before the gases are let out to the atmosphere. These sampling points enable us to measure the exhaust gas content before and after scrubbing. The difference is evaluated and effective control is identified

## 4.3 RESULTS COMPARISON WITH OR WITHOUT AQUA SILENCER:



Fig -5 (a): Results without Aqua Silencer

Fig -5 (b): Results with Aqua Silencer

The following results made through the emission tests taken under the circumstances

- i. Test results are positively obtained, Emission range permitted 4.5% CO at 7800 PPM, In that result achieved is 2.4% CO 6800 PPM.
- ii. In this project 4 stroke, petrol engine is used and observed the emission level is reduced.
- iii. In this lime stone wash method exhaust smoke is reduced 26% compare with normal running vehicles.
- iv. It is observed that air pollution is reduced.
- v. It reduces toxic gases, which effects the human beings and animals.

## 5. CONCLUSION

The previous researchers have dealt about the Power Utilization in inflammable atmospheres and their effects on such environment. Simple methods for reducing the obnoxious particulate of the exhaust have been suggested, when using in such atmospheres. This project analyzed the contents of the exhaust gas before and after treatment and it was found that there is a considerable difference in the percentage of obnoxious products in the emission. After a thorough study of the Chemical Reactions explained in the

previous chapter, and after comparing the emission reports after, with due considerations the following conclusions are derived.

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 emission, thereby serves to suppress a spark before it is emitted to the surrounding environment.
3. In place of water, a weak lime solution is used and this change will allow for the chemical reaction to take place in a faster pace and engine oil (4T) oil is used.
4. All the gases present in the Exhaust except the Carbon Monoxide is readily with the working media namely the limewater and Calcium Carbonate.
5. Water, in turn 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.
6. Nitrogen Oxide (NO) is converted into No<sub>2</sub> after emission, which is highly toxic is mainly absorbed in the water scrubber.
7. The Sulphur-di-oxide content of the Diesel Emission is directly proportional to the Sulphur content of the fuel, and solubility of SO<sub>2</sub> enables some of it to be removed by exhaust water scrubber. However, the choice of fuel remains the primary means of controlling the formation of this toxic and irritant gas.
8. The characteristics smell of the smoke is reduced. Smoke consists of particles of soot mixed with burned or partially burned oil. The unburned hydrocarbons are not highly toxic but they include odor and irritants such as aldehydes. A dissolve of UBHC and other particulate with alkaline solutions, to a considerable extent, the smell of the smoke is reduced when water scrubbers are used.
9. Water is used to absorb heat from the exhaust so that the temperature of the surroundings is reduced while using scrubber tank. After scrubbing the smoke carries water particles, which increases the humidity of the environment.
10. Water scrubbers are having little or no effect on carbon monoxide. But due to its negligible presence in Emission (0.20% by volume) does not pose any health, when compared to Gasoline engines.

## REFERENCES

- [1] Mankhiar Ajay B , Sindhu LS , G. Sasikala, (march 2014) "An Advancement to Reduce Pollution Effectively by Using TI Nanotubes in Aqua Silencer", INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY
- [2] Rawale Sudarshan S.\*, Patil Snehal S (sept 2013) "Use of Aqueous Ammonia in Silencer for removal of CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub> from exhaust gases of I.C. Engines" International Journal of Engineering Science and Innovative Technology, Volume 2, Issue 5
- [3] 3. Mr. SWASTIK R. GAJJAR (june 2014) "Design And Development Of Aqua Silencer For Two Stroke Petrol Engine" International Journal for Innovative Research in Science & Technology Vol. 1, Issue 1
- [4] P.Balashanmugam, G.Balasubramanian (Jan 2015) "Developments of Emission and Noise Control Device (Aqua Silencer)" International Journal of Modern Trends in Engineering and Research Vol 02, Issue 4
- [5] K. Kannan and M. Udayakumar (oct 2009) "NO<sub>x</sub> AND HC EMISSION CONTROL USING WATER EMULSIFIED DIESEL IN SINGLE CYLINDER DIESEL ENGINE" APRN Journal of Engineering and applied sciences Vol 4 no 8
- [6] Gurumoorthy S. Hebbar ,Anantha Krishna Bhat ( aug 2012) "Diesel Emission Control . by Hot EGR and Ethanol Fumigation an Experimental Investigation" International Journal of Engineering and Research development
- [7] Amruthraj M, Nataraj. J.R and Sushmit Poojary (oct 2009) "NO<sub>x</sub> and HC Emission Control in IC Engines" International Journal of Engineering Research Development , Vol 4 Issue 4