

Emission Control Using Aqua Silencer

^{#1}Shaikh Hannan A, ^{#2}Kale Ajinkya, ^{#3}Patel Shubham, ^{#4}Adekar Jotiram,
^{#5}Jadhav Nikhil

¹hannanahmed1428@gmail.com

^{#1}Graduate Student, Mechanical Engineering

^{#2}Assistant Professor Department of Mechanical Engineering,

SKN Sinhgad Institute of Technology & Science,
Lonavala, Maharashtra, India.



ABSTRACT

Petrol power inevitably finds a very important role in the development of the plant's economy and technical growth. In spite of their high thermal efficiency, one cannot ignore the fact about the effect of their exhaust, in the atmosphere. It is a well-known fact that the toxic gases emitted in petrol engines are less. Due to the high cost of diesel engines; petrol engines are more in use. Anticipating the use of petrol engines, even more in the near future; this system developed can be used for emission control. These toxic gases are harmful not only to the atmosphere, but also to the human beings and animals. The objective of this project is to design & fabricate a simple system, where the toxin levels are controlled through chemical reaction to the more acceptable level. 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. This system is very cost effective and more economical.

Keywords: Petrol engine, toxic gases, silencer, emission control

ARTICLE INFO

Article History

Received: 24th July 2017

Received in revised form :

24th July 2017

Accepted: 27th July 2017

Published online :

27th July 2017

I. INTRODUCTION

Petrol 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, Petrol fuel is evidently indispensable. In general, the consumption of fuel is an important aspect for finding out the economic strength of any country. We cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. It is especially so, in most developed countries like USA and EUROPE. While, constant research is going on to reduce the toxic content of petrol exhaust, the petrol power packs find the ever increasing applications and demand. This project is an attempt to reduce the toxic content of petrol exhaust, before it is emitted to the atmosphere. This system can be safely used for petrol power packs which could be used in inflammable atmospheres, such as refineries, chemical processing industries, open cast mines and other confined areas, which demands the need for petrol power packs. For achieving this toxic gases are to be reduced to acceptable limits before they are emitted out of this atmosphere, which otherwise will be hazardous and prone to accidents. The principle involved 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. The highly dangerous carbon monoxide is not such a problem in petrol exhaust, as it does not exceed 0.2 percent by volume, whereas in diesel engines the CO content may be as high as 10 percent. A lime stone container in the scrubber tank reduces the considerable percentage of sulphur-di-oxide presents in the exhaust. The provision of suitable baffles in the scrubber tank aids the turbulence so that, thorough scrubbing take place. The bell-mouth solution, reduces the back pressure. 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 initiated.

A. Problem Definition

Development of petrol and diesel engines in recent years has led to increase in pollution levels of exhaust gases resulting in degradation of environment and human health. In order to control pollution levels, innovations are necessary in automobile industries. One of such innovation 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.

B. Objectives

There has been an increasing concern in recent years over the excessive use of transportation and discharge of industrial waste waters into environment. The engine emission contains air pollutants that are toxic in nature. Some of the examples are CO, CO₂, NOX, and Hydrocarbon. 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.

II. LITERATURE REVIEW

Alen M.A., Akshay M. et al have discussed that the aqua silencer is more effective in the reduction of emission gases from the engine exhaust using perforated tube, lime water and charcoal by using perforated tube the back pressure will remain constant and the sound level is reduced. By using perforated tube the fuel consumption remains same as conventional system by using water as a medium the sound can be lowered and also by using activated charcoal in water we can control the exhaust emission to a greater level. The water contamination is found to be negligible in aqua silencer. It is smokeless and pollution free emission equivalent to the conventional to the silencer. [1]

P. Balashanmugam and G. Balasubramanian have stated that aqua silencer serves to dissolve the unburned hydrocarbon, which is present in the Petrol emission, thereby serves to suppress a spark before it is emitted to the surrounding environment also weak lime solution could be used and this change will allow for the chemical reaction to take place at a faster pace.[2]

Akhil Anil Kumar, Anoop N. et al have discussed that aqua silencer is successfully effective in reducing emission of gases from the engine exhaust. 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 analysed 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.[3]

III. WORK DONE

A. Design Considerations:

The exhaust gas contains carbon – di – oxide, sulphur – di – oxide, carbon monoxide and other oxides of nitrogen. At full load, the temperature of the exhaust gas will lay anywhere between 500°C to 700°C. The pressure of the exhaust gas depends upon so many factors viz.,

- The design of exhaust gas manifold

- Magnitude of valve overlaps
- Engine speed
- Number of cylinders
- The length of the exhaust gas flow path, etc.,

The design of exhaust gas manifold is very important in case of high speed petrol 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.

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. 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 back pressure. The lime stone container is used to store the limestone and offers a definite and increased resistance to flow, which again contributes to the increase of backpressure. The limestones are originally intended to reduce the toxic ingredients of the exhaust gas through chemical reaction. It's evidently affected the flow of resistance and hence the combustion characteristics of the engine will finally contribute the increased toxic ingredients of the exhaust gas. So, while all the above factors contribute for the increased backpressure of the system, the system has to be so designed or constructed to reduce the above increase of pressure to its original intended value or original designed value of the engine exhaust system. This could be in principle, accomplished by so many ways. Basically, the elimination of a separate silencer will solve the problem, because the scrubber tank will act as a silencer and hence the resistance offered by a separate silencer, which is eliminated totally. The introduction of the bell-mouth

assembly facilitates the exhaust gas to expand many times by volume gradually before it is coming in contact with the water in the scrubber tank. The process in itself contributes to the reduction of pressure of the whole system. While, designing the system, we have to be very careful so as not to increase the back pressure unduly which will affect the performance of the engine in the negative direction and so the constant of the exhaust gases. Hence, it is absolutely essential to make a provision for the measurement of back pressure in the system, so, that it can be controlled the same if necessary occurs. This ensures not only the safety, but enhances the performance of the system as a whole.[2]

B. Working Principle:

This section examines the first two of these problems and suggests means by which they may be reduced or overcome. In addition to heat and water vapour, the pollutants in petrol 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 petrol engine exhaust are to be controlled by the scrubbing method, details of which are followed. The high temperature high pollutant exhaust gas is allowed to pass through the bell – 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. The venturi effect of the bell – mouth is minimized because the exhaust gas escapes out of the bell – mouth randomly along the periphery. After expansion, the emission comes in contact with oil; (which could be otherwise being any alkaline solution) where the obnoxious products of combustion are scrubbed when bubbled through it. The bell – mouth also allows for more contact area with water, so that effectively 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. After bubbling through the oil, it comes in contact with bubbles, which encourage turbulence of the exhaust gas with in and below the oil surface without unduly increasing the back pressure of the exhaust. This allows for the thorough scrubbing of the emission, so that more obnoxious product is absorbed in the allowed time.

Chemical Reaction 1

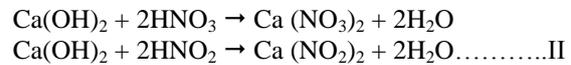
The obnoxious product of combustion is NO_x – the oxides of Nitrogen. Water will absorb the oxides of Nitrogen to a

larger extent. The following chemical reaction will enhance the proof, for the above statement.



Chemical Reaction 2

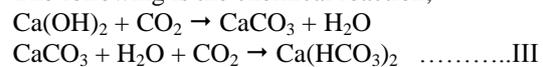
If a small amount of limewater is added to scrubber tank, further reaction takes place as below.



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,



Chemical Reaction 4

The sulphur-di-oxide present in the Petrol 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.



Chemical Reaction 5



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 as mentioned in equation 5.

C. Specifications:

Alkaline solution - Lime Water (Ca(OH)₂)
Water level from bottom - 150mm
Chemical - Lime stone (CaCO₃)
Bell mouth bottom portion
Submerged in the alkaline solution - 25mm
Cooling system – Water
Scrubber tank

D. Selection Of Material

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, 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.

E. 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.

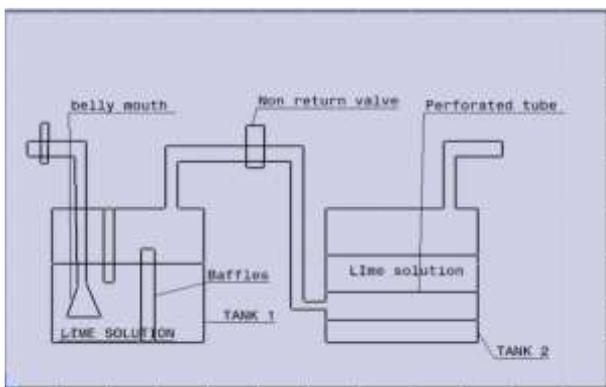


Fig. Schematics of the system

| Sr. No. | Constituent | Minimum | Maximum |
|---------|-------------------|-----------|-----------|
| 1. | Hydrocarbon, (HC) | A few ppm | 1000 ppm |
| 2. | NOx | 100ppm | 2000 ppm |
| 3. | RCD | few | 100 ppm |
| 4. | CO | zero | 2 percent |

Table 1. Range of concentration of different constituents of petrol exhaust[2]

IV. CONCLUSIONS

After a thorough study of the Chemical Reactions explained in the previous chapter, and after going through the Petrol Emission Analysis, 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 serves to dissolve the unburned hydrocarbon, which is present in the Petrol 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.

A. Future Scope

1. Chemical reactions can be intensified in case of oxides of Nitrogen by providing water sprayer immediately after the exhaust manifold of the engine. This will allow the water to have intimate contact with oxides of the Nitrogen before coming to water scrubber. This allows more time for the chemical reaction to take place. To certain extent, this will compensate the loss of the water level inside the scrubber due to evaporation.
2. To reduce the surface temperature of the exhaust gas pipe, asbestos rope could be coiled over, so that there may not be a direct contact surface with the inflammable atmosphere around.
3. Catalytic exhaust scrubber gives significant reductions in most of the pollutants including the highly dangerous CO. however; sufficient additional heat may be produced during the catalytic process to encourage the production of NOX (NITROGEN OXIDE) & the highly toxic NO₂.

REFERENCES

- [1] Alen M.A., Akshay M. et al, "Fabrication and Testing of Aqua Silencer", International Research Journal of Engineering and Technology (IRJET), Volume 02 Issue 05, August 2015.
- [2] P. Balashanmugan, G. Balasubramanian, "Developments of Emission and Noise Control Device (Aqua Silencer)", IJMTER- International Journal of Modern Trends in Engineering and Research, Volume 02, Issue 01, January-2015 (e-ISSN:2349-9745)

[3] Akhil Anil Kumar, Anoop N. et al, "Design and Development of Aqua Silencer", International Journal of Engineering and Innovative Technology (IJEIT) Volume 5, Issue 11, May 2016.

[4] Rawale Sudarshan S., Patil Snehal S., et al, "Use of Aqueous Ammonia in Silencer for Removal of CO₂, SO₂ and NO_x from Exhaust Gases of I.C. Engines", International Journal of Engineering Science and Innovative Technology (IJESIT), Volume 02, Issue 5, September 2013.

[5] Sunderraj S., Madhankumar P.M., Natarajan S. "Experimental Investigation Of Urea-SCR In C.I. Engine Fueled With Diesel And Jatropa Blends", International Journal of Innovative Research in Science, Engineering and Technology, Volume 03, Issue 4, April 2014.

[6] www.wikipedia/aquaammonia/properties.com

[7] www.wikipedia/limewater/properties.com

[8] Keval I. Patel, Swastik R. Gajjar "Design and Development of Aqua Silencer for Two Stroke Petrol Engine", International Journal of Innovative Research in Science and Technology, Volume 01, Issue 1, June 2014.