

Experimental Investigation and testing of Diesel engine and Analysis of exhaust gases by using Aqua Silencer

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ABSTRACT

Diesel 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. Due to the high cost of petrol; diesel engines are more in use. Anticipating the use of diesel engines, even more in the near future; this system developed can be used to control the toxic gases, coming out of the diesel engines.

The objective of this project is to design & fabricate a simple system, where the toxin levels are controlled through chemical reaction to the more agreeable level. This project is an attempt to reduce the toxic content of diesel exhaust, before it is emitted to the atmosphere.

Keywords- Diesel engines, scrubber tank, Aqua silencer, exhaust gas manifold

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I. INTRODUCTION

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.

This project is an attempt to reduce the toxic content of diesel exhaust, before it is emitted to the atmosphere. This system can be safely used for diesel 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 diesel 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.

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 or sat apparatus or exhaust gas analyzer.

Problem Statement:

We studied and found out that 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. 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. Our aim in this project is to design equipment that reduce 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.

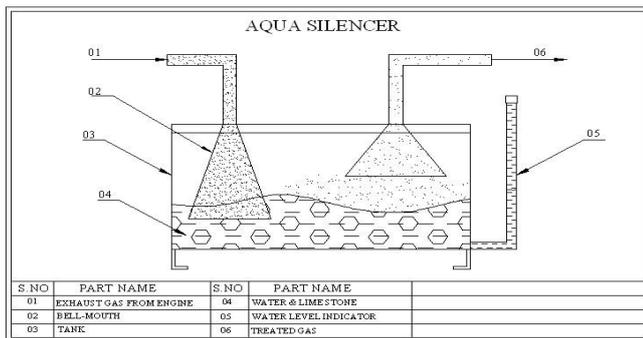


Fig 2.1: Schematic Representation of Aqua Silencer

Constructional Features

The outlet pipe from the engine was connected to the scrubber tank. The nominal bore of the pipe is 41mm, which is also the inlet diameter of the scrubber tank. The shape and length of the pipe are decided according to the space available to keep the flow resistance to a minimum. 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.

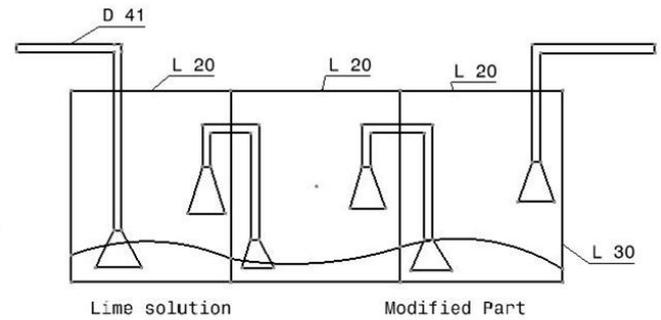


Fig 2.2: Construction of Aqua Silencer

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.

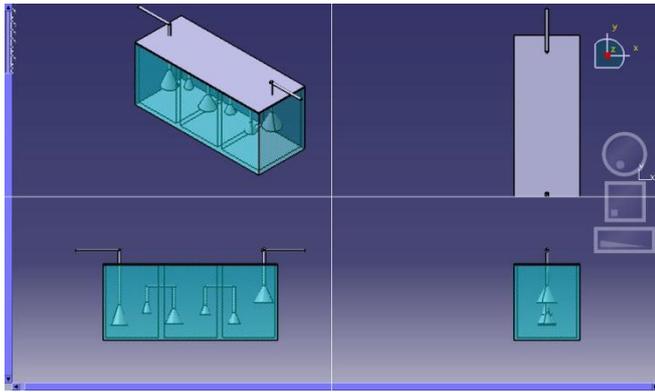


Fig 3.1: 3D Views of Aqua Silencer

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,

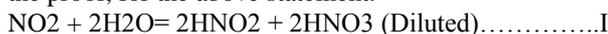
- Carbon monoxide (CO)
- Carbon dioxide (CO₂)
- Oxides of Nitrogen (NO_x)
- Sulphur dioxide(SO₂)
- Particulate and Unburned Hydrocarbons (UBHC)
- Respirable combustible Dust (RCD)

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.

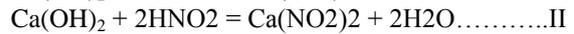
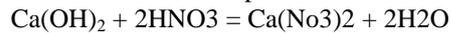
Chemical Reaction 1

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.



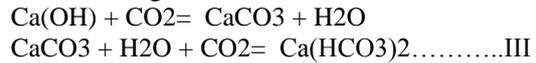
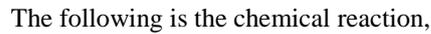
Chemical Reaction 2

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 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.



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.

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.

Table4.1: 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

- a. Blue – white smoke,
- b. 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

Modifications to be done to improve efficiency

1. Chemical reactions can be intensified the 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 NO (Nitrogen Oxide) & the highly toxic NO₂.
4. After a few hours of service, the water in the scrubber will definitely acquire acidic qualities. For avoiding corrosion on the internals of the scrubber are to be zinc coated. If the load is more, stainless steel cladding is recommended.

5. Including the routine maintenance, the water in the scrubber and the limestone are to be changed after of operation in order to maintain the scrubbing efficiency of the water scrubber.

6. Joints may be provided with metallic Gaskets to ensure long life and perfect sealing.

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.

V. 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.

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It is indeed a great pleasure and moment of immense satisfaction for we to present a project report on “Experimental Investigation and testing of Diesel engine and Analysis of exhaust gases by using Aqua Silencer” 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.

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