

A Review on Developments in Charcoal Silencer

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Abstract - Air pollution is most important from the public health of view, because every individual person breath approximately 22000 times a 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 dexterous effect on life upon our planet. The main pollutants contribute by automobile are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOx) and Lead. Automobiles are not the only sources 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 of our environment from degradation. An Aqua 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 hearable 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 silencer and hence its name AQUA SILENCER. The noise and smoke level is considerable less than the conventional silencer, it is cheaper, no need of catalytic converter and easy to install. It is imperative that serious attempts should be made to conserve earth's environment from degradation. An aqua silencer is an attempt in this direction; it is mainly dealing with control of emission and noise.

Keywords: silencer, perforated tube, charcoal, non-return valve, limewater.

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. In general, the consumption of fuel is an index for finding out the economic strength of any country. Inspire, 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 diesel exhaust, the diesel power packs find increasing applications and demand. 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. The highly dangerous carbon monoxide is not such a menace in diesel exhaust, as it does not exceed 0.2 percent by volume, whereas in petrol 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 dioxide 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, while reducing 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.

II. LITERATURE REVIEW

Zhang[1]: The outflow velocity distribution and inner pressure distribution could be improved by improving the structure of silencer, Therefore modifying inner area Section or reducing the area of shell & end cover.

Ying-li Shao[2]: The new exhaust mufflers obviously effective in controlling the low-frequency exhaust Noise. This experiment reduce noise of the Engine.

X. Liu, Y.D.Deng, S.Chen, W.S Wang, Y.Xu[3]: A research was carried out to test three cases about the installation position of the thermoelectric generator then various cases were tested.

M.Hatami, D.D.Ganji, M.Gorji- Bandpy[4]: In this paper, engines exhaust waste heat is recovered by using the finned type heat exchangers numerically. Heat transfer through the walls and fins were modeled successfully and the transferred heat to cold fluid is calculated as the recovered heat.

Mohsen Ghazikhani, Mohammad Hatami ,BehrouzSafa, DavoodDomiriGanji[5]: Results of scavenging and trapping efficiencies are more in accordance with the perfect mixing

model. This is due to rapid evaporation of ethanol in the entrance to cylinder and makes better mixing. By increasing the delivery ratio, the scavenging efficiency increases due to increase in the inlet mass, but increasing the delivery ratio reduces the trapping efficiency.

III. 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 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 impossible to avoid unless there is 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 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. 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 is 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. Because of the introduction of the scrubber, the net length of the exhaust gas flow path is also increased which is again against the original intention. So, 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 have way sole the problem, because the scrubber tank, it'll 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.

IV. COMPONENTS AND EXPLANATION

1. Perforated tube: The perforated tube consists of number of holes of different diameters. It is used to convert high mass bubbles to low mass bubbles. The charcoal layer is pasted over the perforated tube.
2. Charcoal layer: The charcoal layer has more absorbing capacity because it has more surface area. This charcoal is called as 'Activated Charcoal'. It is produced by heating the charcoal above 1500 °c for several hours in a burner. Its surface area gets increased.
3. Outer Shell: The whole setup was kept inside the outer shell. It is made up of iron or steel. The water inlet, outlet and exhaust tube was provided in the shell itself.
4. U- Bend: The U Bend is provided instead of a non-return valve which is a mechanical device, which normally allows fluid (liquid or gas) to flow through it in only one direction. The Aqua silencer was filled with water and it is directly connected to the exhaust pipe of the engine. There is a chance for the water to get enter into the engine cylinder. To avoid this, U bend is used.
5. Flange: A flange joint is a connection of pipes, where the connecting pieces have flanges by which the parts are bolted together. Here flange is used to connect the silencer to the engine.

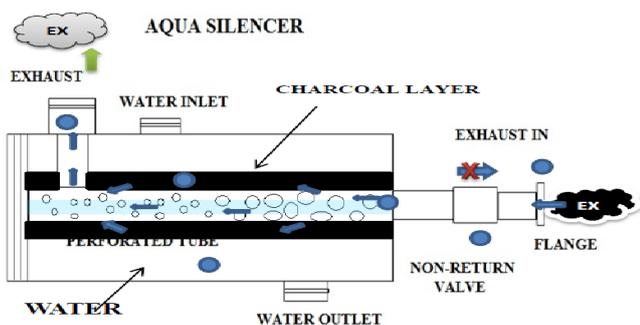


Figure: Perforated tube

V. 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.

VI. WORKING PRINCIPLE



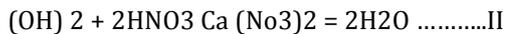
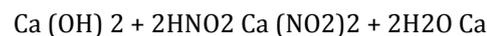
As the exhaust gases enter in to the aqua silencer, the perforated tube converts high mass bubbles in to low mass bubbles after that they passes through charcoal layer which again purify the gases. It is highly porous and possess extra free valences so it has high absorption capacity. After passing over the charcoal layer some of the gases may dissolved into the water and finally the Exhaust gases escape through the opening in to the atmosphere. Hence aqua silencer reduces noise and pollution. Following chemical reactions takes place in aqua silencer:

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.



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



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-dioxide, calcium-bi-carbonate will be precipitated. The following is the 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.



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.

VII. EXPERIMENTAL ANALYSIS AND RESULT OF AQUA SILENCER

Basically a perforated tube which is installed at the end of the exhaust pipe. The perforated tube consists of number of holes of different diameters 8mm, 4mm, and 2mm. It is used to convert high mass bubbles to low mass bubbles. It is made from the stainless steel. The charcoal layer is pasted over the perforated tube. Bead Activated carbon is used as a charcoal layer. It is a process by which the carbonized product develops porous structure re of molecular dimensions and extended surface area on heat treatment in the temperature re range of 800 –1000 o C in presence of suitable oxidizing gases such as steam, CO2. Bead activated carbon is made from petroleum pitch and supplied in diameters from approximately 0.35 to 0.80 mm. It is also noted for its low pressure drop, high mechanical strength and low dust content, but with a smaller grain size. Its spherical shape makes it preferred for fluidized applications. 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. It is made up of iron or steel. The water inlet, outlet and exhaust tube was provided in the shell.

VIII. OPERATIONAL AND PHYSICAL PARAMETER

1. Perforated Tube Perforated tube diameter is 1.5 inch because engine exhaust manifold dia. is same and 12 inch long as per design data and made from the stainless steel because it has a high melting point 1510o C.

2. Effect of Change in Porosity and Change in Diameter of Perforation Hole on Backpressure .It is observed that for the smallest hole diameter of 5 mm the back Pressure is as high as 13,837 Pa. If we increase the diameter of the hole back pressure rapidly falls down and it is lowest i.e. 788 Pa for the hole diameter 12.5 mm.

3. Activated Carbon x Size - 0.35 to 0.80 mm x Shape - Cylindrical palates

4. Specification of Engine

- Stroke - Two stroke petrol engine.
- Type - Air cooled
- No. of cylinder - Single cylinder
- Bore x Stroke - 42.6 mm x 42 mm
- Displacement - 59.9 cc
- Maximum Power - 3.5 hp at 5500 rpm
- Max. Torque - 4.5 Nm at 5000 rpm

5. Water

- Thermal properties of water
- Maximum density - 1000 kg/m³
- Specific weight - 9.807 KN/m³
- Freezing point - 0 o C x Boiling point - 100 o C
- Latent heat of melting - 334 KJ/Kg
- Latent heat of evaporation - 2270 KJ/Kg x
- Specific heat - 4.187 KJ/KgK
- Thermal expansion - 4 o C to 100 o C

6. Effects of Dissolved Gases on Lime Water

The lime water is a good absorbing medium. In aqua silencer the gases are made to be d dissolved in lime water. When these gases dissolved in water they form acids, carbonates, bicarbonates etc.

a)Action of dissolved SO₂ When SO_x is mixed in water, it form SO₂, SO₃, SO₄, H₂SO₄ i.e. sulphur Acid (H₂SO₃), it forms Hydrogen Sulphide which causes rotten egg smell , acidify and corrosion of metals.

b)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.

c)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 effected by Nitrogen. Nitrate usually occurs in trace quantities in exhaust gas.

d)Adsorption 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.

IX. MERITS AND DEMERITS

1. Merits

- When the engine is running, no vibrations are occur.
- Easy start the engine.
- Greater control of emission and noise level.
- Precipitation of carbon occur.

2. Demerits

- Once in a year, lime water filling is mandatory.
- Compared to conventional silencer, Silencer weight is more
- More space is required than conventional silencer.

X. RESULTS AND DISCUSSION

First we determine the amount of exhaust gas like hydrocarbons, nitrogen etc. which is p resent in the single cylinder diesel engine without connecting Zero emission silencer. And then aqua silencer (without lime water) is connected on the exhaust and determines the amount of exhaust gas by smoke analyzer. At last the silencer (with lime water) which is connected to exhaust pipe and readings are taken. The results which are obtained from t he project analysis is given below in the tables. Smoke analyzer tests were carried out for analyzing the performance of the silencer.

XI. CONCLUSION

The aqua silencer is more effective in the reduction of mission of 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. It can be also used both for two wheelers and four wheelers and also can be used in industries.

XII. SCOPE FOR FUTURE RESEARCH

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. Among the air pollutants, all are most effective pollutants. Hence, the removal of pollutants was selected for the present study. Several expensive techniques are available in developed countries. But in developing countries like India is not applicable since adsorption technique is less expensive and economically feasible, it has been selected for the present study using some cheap cost chemicals as an effective adsorbent. Therefore the objective of the present work was to test the ability of some chemicals in removing air pollutants from engine emission. In future researches are going on to develop an aqua silencer which can be fitted in to automobiles without effecting its aerodynamics properties and efficiency.

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