A COMPREHENSIVE STUDY ANALYSIS OF AQUA SILENCER FOR DIESEL VEHICLES

Dr.A.Anbarasu[*1], Dr.T.Mayavan[2], B.Balamugundan[3], R.Suthan[4]

[*1,2,3,4]Department of Mechanical Engineering, Panimalar Engineering College, Chennai, Tamilnadu, India
aanbarasu71@yahoo.com[*1], mayavant@gmail.com[2], mugundan7503@gmail.com[3], itsmesuthan@gmail.com[4]

Abstract

Diesel engines are used in a variety of industries, including road and sea transportation, agriculture, mining, and many others. Diesel fuel is clearly indispensable, given the available fuel resources and current technological development. In general, fuel consumption is used as an indicator of a country's economic strength. Nonetheless, we cannot ignore the negative effects of the large volume of burned gases, which erodes the purity of our environment on a daily basis. This is especially true in the most developed countries, such as the United States and Europe. While constant research is underway to reduce the toxic content of diesel exhaust, diesel power packs continue to find new applications and decommission.This project aims to lower the toxic content of diesel exhaust before it is released into the environment. This system can be used safely for diesel power packs in flammable environments, such as refineries, chemical processing industries, open-pit mines, and other confined areas where diesel power packs are required. To do so, toxic gases must be reduced to acceptable levels before being released into the atmosphere, which would otherwise be dangerous and prone to accidents.

IndexTerms: Aqua Silencer, Diesel engine, Emission, Diesel Exhaust, Emission, Chemical Industries.

I. INTRODUCTION

The principle is that the exhaust gas is bubbled through an alkaline solution in a scrubber tank, where the temperature of the gases is reduced and most of the nitrogen oxides in the exhaust are rendered non-toxic. Carbon monoxide, which is extremely dangerous, is not a threat in diesel exhaust because it does not exceed 0.2 percent by volume, whereas CO content in petrol engines can be as high as 10%. In the scrubber tank, a lime stone container reduces the amount of sulphur – di – oxide present in the exhaust.The use of appropriate baffles in the scrubber tank aids turbulence, allowing for thorough scrubbing. While reducing back pressure, the bell – mouth solution is used. Samples are taken between the engine outlet and the scrubber inlet, as well as after the scrubber outlet before the gases are released into the atmosphere, to determine the contents of the exhaust gas. We can measure the exhaust gas content before and after scrubbing using these sampling points. The disparity is assessed, and effective control is implemented. The samples are analyzed using the system's orsat apparatus.

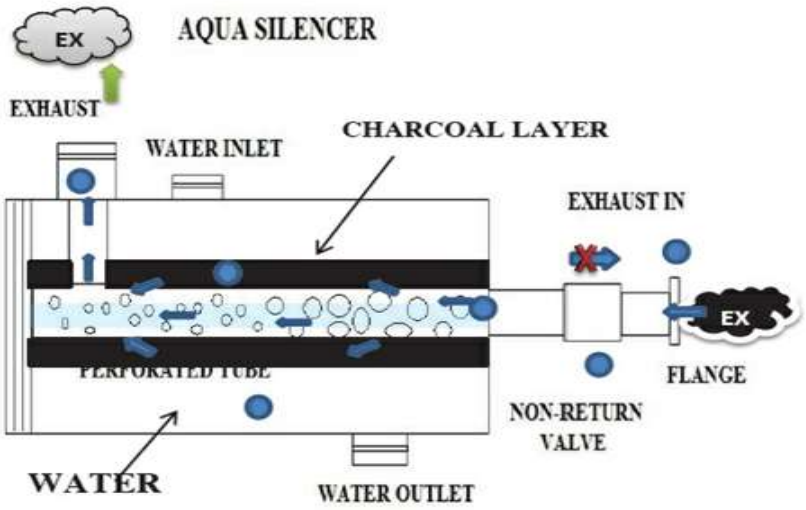

Fig.1 Working of Aqua Silencer

Carbon – di – oxide, sulphur – di – oxide, carbon monoxide, and other nitrogen oxides are all present in the exhaust gas. The temperature of the exhaust gas at full load will range from 500°C to 700°C. The pressure of the exhaust gas is determined by a number of factors, including:

1.The design of exhaust gas manifold
2.Magnitude of valve overlap
3.Engine speed
4.Number of cylinders
5.The length of the exhaust gas flow path, etc,

In the case of high-speed diesel engines, the exhaust gas manifold design is crucial. The exhaust gas manifold is designed so that the gases that come out of the cylinder flow very smoothly before being released into the atmosphere, in order to keep the exhaust gas pressure within acceptable limits. This is critical in order to keep the back pressure within safe limits and the engine operating at its best.If the back pressure is allowed to exceed the predetermined level, the piston's effort to scavenge is greatly increased, and thus power is lost in doing so. As a result, the primary consideration when introducing any modification to the exhaust system is that it does not and shall not increase the back pressure, which has a significant impact on the engine's performance characteristics. To be more precise, the combustion characteristics of an engine are affected by the engine's speed for a given specific fuel consumption rate.

As a result, the combustion is not complete or proper, resulting in an increase in impurities or unburned gases. This principle works against the introduction of any system whose sole purpose is to reduce the extremely toxic properties of exhaust gas. As a result, it is implied that the introduction of any system that reduces the toxic property of exhaust gas will not have any negative consequences. As a result, adding any component to the system increases the length of the flow path and the resistance to flow.As a result, an increase in back pressure is unavoidable unless the magnitude of the increase is compensated in the component's design. Considering the factors relevant to this project's specific application, the addition of a scrubber tank will undoubtedly increase back pressure. The following are the factors that will contribute to an increase in back pressure in the scrubber tank.

A small amount of fuel is introduced into the intake manifold during fumigation. Because intermediate products like peroxides and aldehydes react with oxygen more quickly than original hydrocarbons, this starts pre–combustion reactions before and during the compression stroke, resulting in a shorter chemical delay. Thermal cracking, which causes soot formation, is reduced by shortening the delay period.Because it takes about 80 kcal/mole to beak a double bond C=C, cracking may not occur at all. This energy may not be available due to easy oxidation during pre–combustion reactions. The best smoke reduction is achieved with a fumigation rate of 11 to 15%. This improvement, however, varies greatly depending on engine speed. At low engine speeds, 50 to 80 percent less smoke is produced. As speed increases, these decreases until there is no longer any effect of fumigation.

To date, no instruments or analytical procedures have been able to evaluate the problem of odor measurement. The state of the art in odor measurement is still in the early stages of development, and it will be at least a few years before a reliable odor measurement method emerges. The most common method for determining odor intensity is to use a human panel. Various investigators, including Turk, have attempted to standardize this method, but all of them are unreliable due to numerous human factors that obstruct such evaluations.As a result, the following discussion of the odor problem takes a broad approach, and no specific or rigid rules can be established. The pungent odors of diesel exhaust are thought to be caused by members of the aldehyde family. Even though the amount of aldehydes is low, less than 30 ppm, concentrations as low as 1 ppm irritate the eyes and nose of humans.

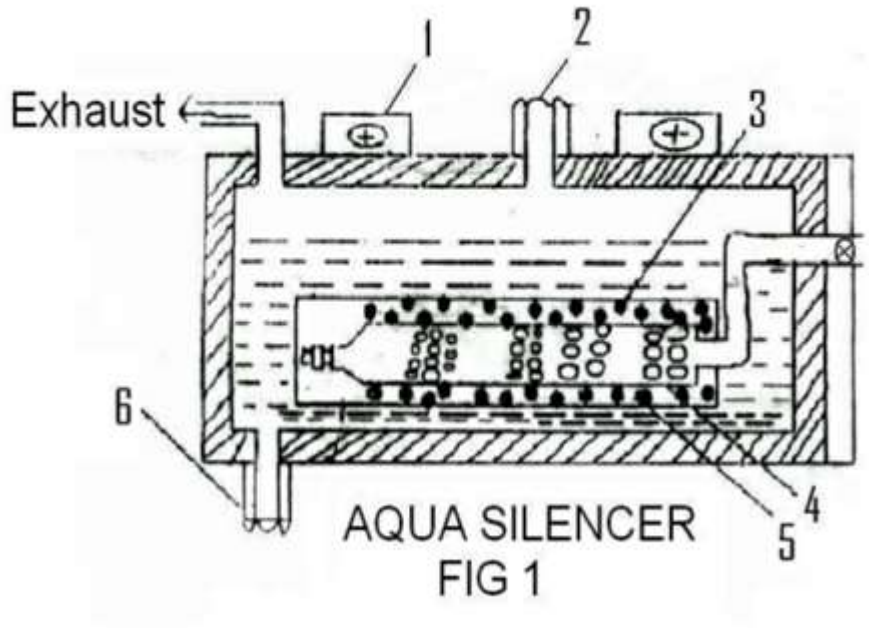

Fig.2 Typical Working of Aqua Silencer

Diesel exhaust odor has an intensity rating that indicates how objectionable it is. A number of odor-producing components, such as nepthaldehyde, a-butylbenzene, and others, are given standard values, and a trained human panel assigns odor ratings to the exhaust samples. Due to the lack of a better method for odor evaluation, this standard has become popular. Due to varying human responses to the same type of odor and other subjective factors, this is subject to error.

II. MATERIALS AND METHODS

2.1 BACK PRESSURE EXERTED BY WATER

Exhaust gas must pass through water that has been added to the tank. In any case, the engine's outlet must be kept below the scrubber tank's water level so that the gas can pass through the water. To bubble through the water, the gas does not need to push the water. To bubble through the water in the tank, the gas must push the water. This could lead to an increase in backpressure.

2.2 BACK PESSUE EXERTED BY BAFFLES

The baffles, which are provided to deflect the exhaust gases, also offers resistance to the flow and intern increases the back, pressure.

2.3 BACK PRESSURE EXERTED BY EVAPORATED WATER PARTICLES

Due to the high temperature at which the exhaust gas is released from the engine, some of the water particles that come into contact with it readily change their phase from liquid to gaseous (steam), increasing the net mass of the exhaust gas flow per unit time. As a result, the backpressure may rise.

2.4 BACK PRESSURE EXERTED BY LIME STONE CONTAINER

The lime stone container is used to store the lime stone and provides a definite and increased resistance to flow, contributing to the backpressure increase. The limestones were created with the intention of reducing the toxic components of exhaust gas through chemical reaction. It clearly affects the flow of resistance, which in turn affects the combustion characteristics of the engine, resulting in increased toxic ingredients in the exhaust gas.

2.5 BACK PRESSURE EXERTED BY EXHAUST FLOW PATH LENGTH

The net length of the exhaust gas flow path is also increased as a result of the scrubber, which is contrary to the original intent. While all of the above factors contribute to increased backpressure in the system, the system must be designed or constructed in such a way that the above increase in pressure is reduced to the engine exhaust system's original intended or designed value. In theory, this could be accomplished in a variety of ways. In essence, eliminating a separate silencer will only solve half of the problem, because the scrubber tank will act as a silencer, eliminating the resistance offered by a separate silencer.

2.6 EFFECT OF BELL – MOUTH IN SCRUBBER TANK

The bell-mouth assembly allows the exhaust gas to gradually expand in volume before it comes into contact with the water in the scrubber tank, allowing it to expand many times its original volume. The process itself contributes to the overall system's pressure reduction. The system must be carefully designed to avoid excessively increasing backpressure, which will negatively affect the engine's performance and, as a result, the exhaust gas constant.. As a result, it is critical to include a provision for the measurement of backpressure in the system so that it can be controlled if necessary. This not only ensures safety, but also improves the overall performance of the system.

2.7 OUTLET PIPE FROM THE ENGINE (OR) INLET TO THE SCRUBBER TANK

The scrubber tank was connected to the engine's outlet pipe. The pipe's nominal bore is 50mm, which is also the scrubber tank's inlet diameter. To keep the flow resistance to a minimum, the pipe's shape and length are determined by the available space.

2.8 ASSEMBLY

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

1. Tank.
2. Outlet, Inlet.
3. Charcoal container
4. Drain Assembly.

2.9 TANK FABRICATION

The tank is made of standard steel pipe of 5mm thickness. The tank is fabricated using Electric Arc Welding process to withstand a maximum pressure of 0.8N/mm2 [8Kg/Cm2], with leak – proof.

2.10 DESIGN CONSIDERATIONS

Given the size of the Bell-mouth and lime stone container to be accommodated inside, the tank has a capacity of 5 liters. The tank's maximum water capacity is approximately 3 liters, which corresponds to a water level of 115mm from the tank's bottom. Appropriate baffles are provided to encourage through scrubbing of exhaust gas. Water is also kept out of the stone container to a large extent by the baffles.

2.11. Charcoal Container Fabrication

The container is made of standard steel plates, which has 3mm thickness of quality steel pipe.

2.12. DESIGN CONSIDERATIONS

The charcoal container is designed to hold charcoal with a cross sectional area of 60 – 80mm (approx.). The container's capacity is less than 2 liters. Charcoal should only be placed below the outlet portion of the tank, which is above the top plate. The container's circular sidewalls are equipped with suitable holes. Because the effective area is greater than the effective area, the easy flow of exhaust gas is facilitated.

2.13. DRAIN FABRICATION

Drain is fabricated using 25.4mm nominal bore pipes where, fabricated using electric arc welding. The surface is rough ground in order to have better finish.

2.14. DESIGN CONSIDERATION

Instead of providing a separate drain plug, a tee welded at the bottom of the level pipe to accommodate the drain plug.

2.15. OUTLET PIPE FROM TANK

The tank's outlet pipe is made of standard medium-duty pipes that meet BIS 1369 specifications. The pipe's nominal bore is 50mm, which is also the inlet pipe's diameter. The flange at the end matches the flange on the lime stone container's outlet. The pipe's shape and length are designed to minimize flow resistance.

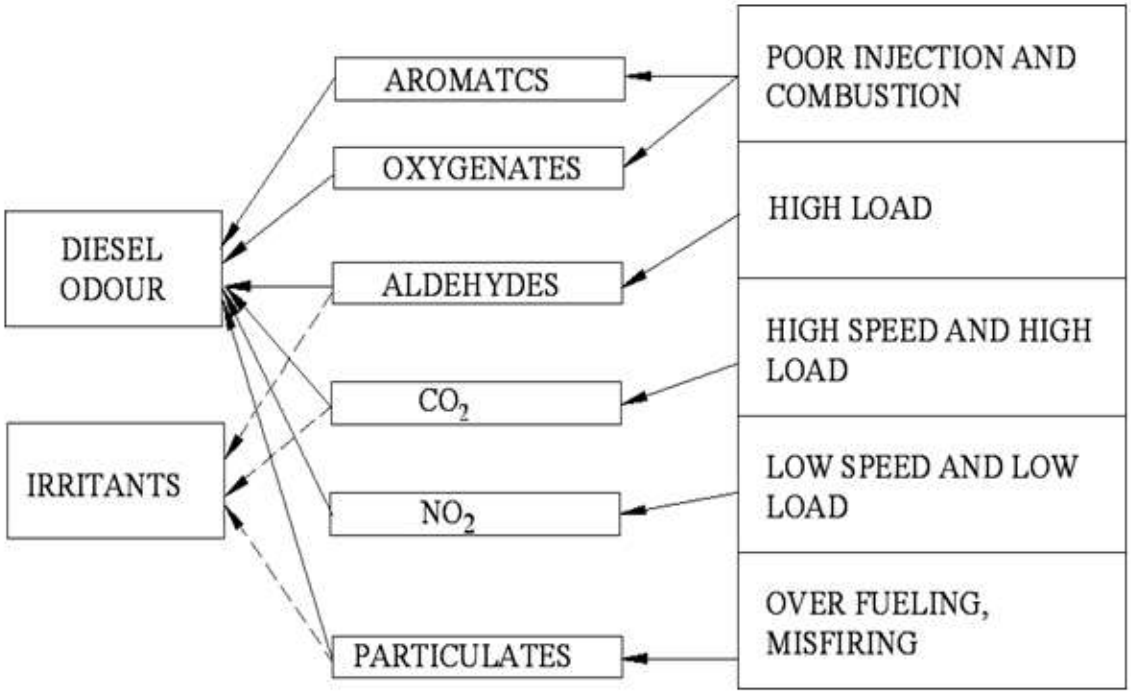

Fig.3Layout of different emission gases from Diesel engine

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

1.Gases and particulate in engine emission.

2.Heat and Humidity.

3.Risk of explosion and fires.

4.Transportation and storage of fuel.

5.High speed in long hauls.

6.Risk of trackless vehicles entering inadequately ventilated areas.

7.Noise.

This section examines the first two of these problems and suggests means by which they may be reduced or overcome.

III. RESULTS AND DISCUSSION

Although the basic reaction that causes soot formation is unknown, the following theories have been proposed.

1. Carbon strongly catalyzes the reaction that produces carbon monoxide (2CO = C + CO2). As a result, when particles are already present in some form, they rapidly accumulate and polymerize.

2. The second theory states that hydrocarbons, particularly heavy ends, decompose into small basic C2 and C3 radicals, which then polymerize to form C6 ring polymers. Because soot has a free valency, it has excellent agglomeration properties and can be absorbed by metal surfaces, making it an effective absorption agent. It is extremely difficult to remove it once it has adhered to the metal.

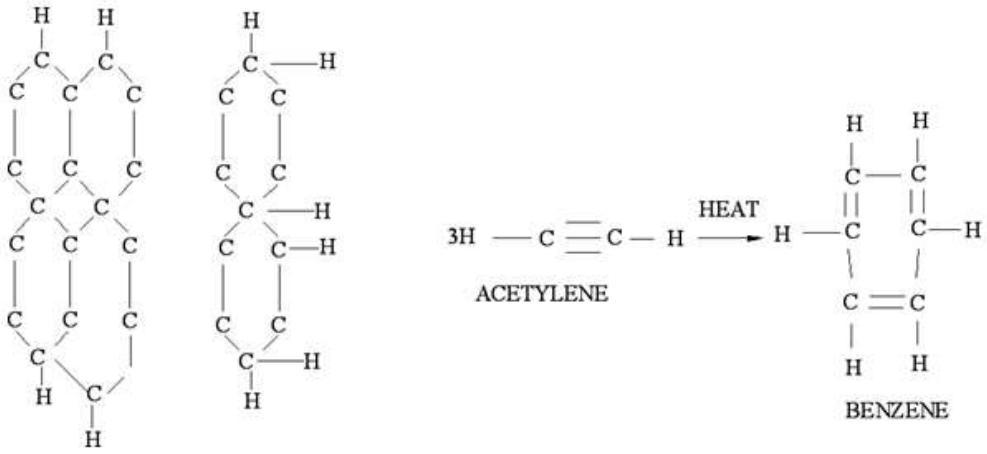

Fig.4 Chemical Reaction mechanism

Using a water and charcoal mixture, the aqua silencer is more effective in reducing emissions from engine exhaust gas. The back pressure will remain constant and the sound level will be reduced if you use a water and charcoal mixture. The fuel consumption with the perforated tube is the same as with the conventional system. Sound can be reduced by using water as a medium, and exhaust emissions can be controlled to a greater extent by using charcoal in water.Because the amount of acidity in aqua silencer is expected to be below the dangerous acidity level, water contamination is found to be negligible. It emits no smoke or pollution and is also very inexpensive. The performance of the aqua silencer is nearly identical to that of a conventional silencer.

3.1 ADVANTAGES

Diesel engines are used in a variety of industries, including road and sea transportation, agriculture, mining, and many others. In light of the available fuel resources and the current situation. With the advancement of technology, diesel fuel has become unavoidable. In general, fuel consumption is used as an indicator of a country's economic strength.

Fig. 5 Completed Aqua Silencer arrangement

3.2 DISADVANTAGE

Need to alter the silencer which may increase the total weight of the vehicle.

3.3 APPLICATION

To achieve this, toxic gases must be reduced to acceptable levels before being released into the atmosphere, which would otherwise be dangerous. Pollution Control Aqua Silencer can also be used in automobiles, industry, DG sets, DG machines, marine, and boats. The advantages of the Pollution Control Aqua Silencer are that it reduces sound [5], CO by 60 to 70% when compared to a standard silencer, and it is inexpensive Because the experimental study of exhaust odor is severely hampered by the lack of standard tests, little progress has been made in this area. There's no point in going into detail about odor test results because the various standards and human panel evaluation procedure have changed so much. The development of a catalytic odor control system containing the muffler and/or catalyst container is underway, and it has been discovered that certain oxidation catalysts, when used under favorable conditions, reduce odor intensity, but the current state of the art still leaves much to be desired. It has been claimed by various manufacturers of odor suppressant additive compounds that they reduce odor.

IV. CONCLUSION

Using a perforated tube, the aqua silencer is more effective in reducing emissions from engine exhaust gas. Sound can be reduced by using water as a medium, as well as using activated charcoal in water. We can increase the level of control over exhaust emissions. Because the amount of acidity in aqua silencer is expected to be below the dangerous acidity level, water contamination is found to be negligible. i.e. 250 mg per liter. It emits no smoke or pollution and is also very inexpensive. The performance of the aqua silencer is nearly identical to that of a conventional silencer. The NOx will be reduced to 29.9% in no-load conditions by using AQUA Silencer,the Particulate Matter will be reduced to 70%. In the Smoke Density will be reduced to 67.36%.

REFERENCES

[1] Automotive Emission Control. William H.Crouse and Donald L.Angling

[2] Environmental Pollution analysis Khopkar Methods of measurement of Air Pollution, Indian standard Institution (ISI)
[3] Engineering Chemistry Jain and Jain.
[4] Waster water engineering treatment. Matecarf and eddy.
[5] Internal Combustion of Engines. M.L. Mathur and R.P.Sharma.