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Developments of Emission and Noise Control Device(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. It is a well-known fact that the toxic gases emitted in diesel engines are less than the engines. 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.These toxic gases are harmful not only to the atmosphere, but also to the human & animal race. 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 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- Diesel engines, scrubber tank, orsat apparatus, Aqua silencer, exhaust gas manifold.

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 EUOPE. While, constant research is going on to reduce the toxic content of diesel exhaust, the diesel power packs find the ever 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 sulfur – 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, while reducing the back pressure. Four 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. The samples are analyzed by using an orsat apparatus of the system.

II. 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 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.

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 limestone's, 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, 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 have way solve the problem, because the scrubber tank, it 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, 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 backpressure 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. Fig 1shows the schematic diagram of the general arrangement of Scrubber tank assembly.

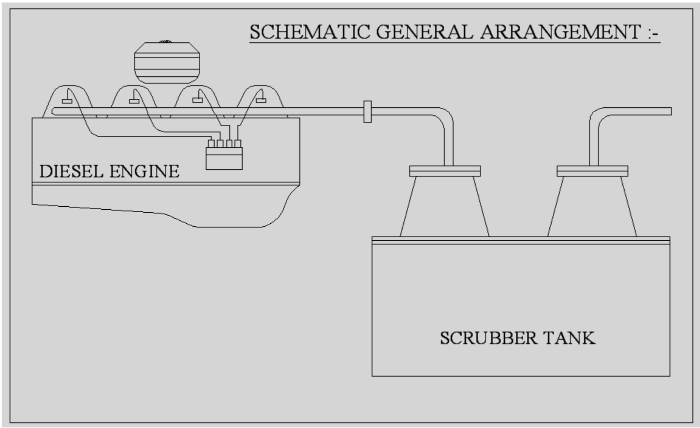

Figure 1: Schematic diagram of general arrangement

III. CONSTRUCTIONAL FEATURES

The outlet pipe from the engine was connected to the scrubber tank. The nominal bore of the pipe is 50mm, 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 structional steel conforming to BIS: 226, Designation ST 42S. The tank is fabricated using Electric Arc Welding processes to withstand a maximum pressure of 0.8N/mm^2 [8Kg/Cm^2], with leak – proof. The tank is 40 liters capacity keeping in view the size of Bell-mouth and lime stone container, which are to be accommodated inside. The maximum water content of the tank is about 15 liters, corresponding to 115mm of water level from the bottom of the scrubber tank. Suitable baffles are provided which will encourage through scrubbing of the exhaust gas. The baffles also prevent entry of water into the stone container to a considerable extent.

The bell – mouth is made of standard steel plates of 3mm thickness of quality structural steel conforming to BIS: 226, Designation ST 42S.The bell – mouth is provided to expand the exhaust gas, so as to reduce the backpressure and temperature. The areas at the inlet portion are about 9025mm^2. At the end where the expansion is complete, the area is about 22500mm^2. This accounts for a total enlargement of more than 2½ times, the area, which is originally available, the overall flow path of ½ times, the area, which is originally available. The overall flow path of the bell – mouth is more than 330mm. The water column inside the bell – mouth is 25 – 30mm maximum. This accounts for a maximum amount water displacement under peak load conditions. The greater amount of expansion and lesser-required water displacement ensures minimum backpressure during the bubbling of exhaust gas. The back pressure can be further reduced by introducing a suitable space between the bell – mouth and tank top flange without necessitating the reduction of water level in the scrubber tank.

The container is made of standard steel plates, which has a 2mm thickness of quality steel plates conforming to BIS: 226, Designation ST 42S – Mild steel Plates, using Electric Arc welding. The stone container is designed to accommodate 35 – 40mm dross sectional area (approx.) limestone. The capacity of the container is less than 2 liters. Limestones are to be only below the outlet portion, which is above the top plate of the tank. Suitable holes are provided at the circular sidewalls of the container. By separating the out let portion, the lime stone container can be easily visible for that cleaning and changing the lime stone becomes very simple. The level plug cum drain is fabricated using 12.7mm nominal bore pipe fittings and conforming to BIS: 1369 Where, fabricated using electric arc welding. The surface is rough ground in order to have a better finish.

The level plug is designed to maintain a level of 115mm inside the tank. Instead of providing a separate drain plug, a tee welded at the bottom of the level pipe to accommodate the drain plug. The whole assembly can be unscrewed and taken out of the tank for periodic maintenance and repair by unscrewing the thread, which is fastening it to the boss, which is welded to the bottom of the tank. Water level indicator is fixed in the tee joint, which shows the level of water in the scrubber tank.

IV. WORKING PRINCIPLE

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.

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 vapor, the pollutants in diesel exhaust are,

- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Oxides of Nitrogen (NOx)
- Sulphur dioxide(SO_2)
- Particulate and Unburned Hydrocarbons (UBHC)
- Respirable combustible Dust (RCD)

The above polluting contents in the diesel 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 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. The venture effect of the bell – mouth is minimized because the exhaust gas escapes out of the bell – mouth randomly along the periphery. Fig 2 shows the aqua silencer.

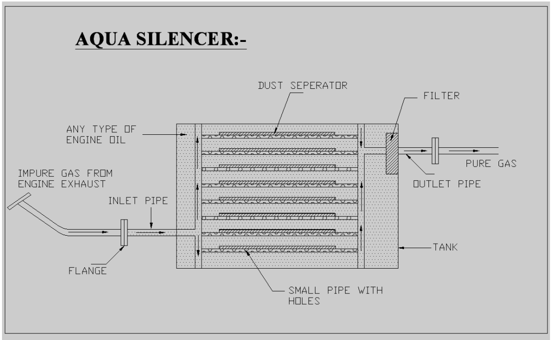

Figure 2: The aqua silencer

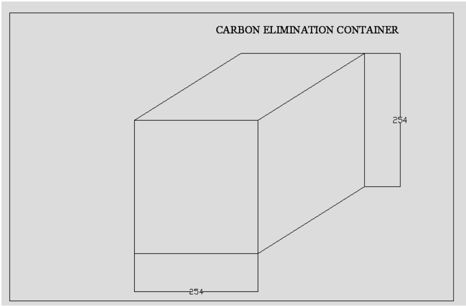

Figure 3: Carbon elimination container

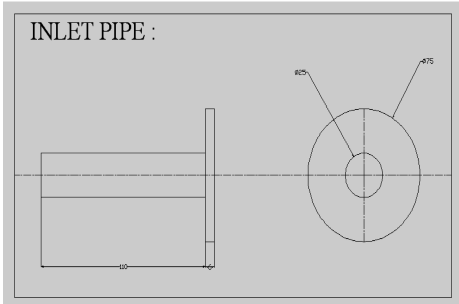

Figure 4: Inlet pipe arrangement

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. Fig 3 shows the Carbon elimination container.

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. Fig 4 shows the inlet pipe arrangement.

The baffles are of invaluable help to reduce the carry-over of oil particles which are converted into steam, which otherwise will escape out of the system. A lime stone container, which is provided above the baffles, allows the exhaust emission to pass through limestone radially.

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 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.

$NO_2 + 2H_2O \longrightarrow 2\ HNO_2 + 2HNO_3$ (Diluted)…………..I

Chemical Reaction 2

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

$Ca(OH)_2 + 2HNO_3 \longrightarrow Ca(No_3)_2 = 2H_2O$
$Ca(OH)_2 + 2HNO_2 \longrightarrow Ca(NO_2)_2 + 2H_2O$……….II

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,

$Ca(OH) + CO_2 \longrightarrow CaCO_3 = H_2O$
$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$……….III

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.

$Ca(OH)_2 + SO_2 \longrightarrow CaSO_3 + H_2O$…………..IV

Chemical Reaction 6

$CaCO_3 + SO_2 + H_2O$ $CaSO_3 + CO_2 + H_2O$…VI

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 CO_2 will again combine with $CaCO_3$ to form calcium bicarbonate as mentioned in equation 5.

V. ANALYSIS OF EXHAUST EMISSION

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 1 shows the Range of concentration of different constituents of diesel exhaust

Table 1.Range of concentration of different constituents of diesel exhaust

Sl.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 2.Emission levels of 4-stroke normally aspirated engine at medium speed & high speed

Sl.No	Emission or Exhaust Quality	At high Speed	At Medium Speed

1.	CO, %	0.14	0.26
2.	CO_2, %	7.79	7.14
3.	UBHC, ppm C	1000.00	370.00
4.	NOX, ppm	790.00	800.00
5.	RCD,ppm	54.00	1.60
6.	SMOKE (Haritridge units)	60.00	60.00
7.	ODOUR, DI units Turk	3.50	3.30
8.	AIR FUEL RATIO	25.00	25.00

Table 3.Emission characteristics of 4 –stroke normally aspirated engine

Sl.No	Emission	Medium Speed	High Speed
1.	Hydrocarbon, (HC)	Low	High
2.	NOX	Low	Low
3.	RCD	Low	High
4.	SMOKE	High	High

Effect of mode of operation of diesel exhaust Idle, full load at rated speed, and acceleration at full rack are the three modes of operation which have been found to significantly affect the emission levels in diesel exhaust as can be seen. During the idle mode the concentration of HC, Nox and aldehyde emissions are lower than other modes the emissions at idle are less significant than during any other mode. The acceleration mode has profound influence on odor. Highest odor occurred when full rack acceleration was encountered. Smoke levels are also high during acceleration Emissions at full load relative to emissions at other operational modes very significantly with engine type. Four –stroke normally aspirated engines smoke very much at rated full load. Table 2 shows the Emission levels of 4-stroke normally aspirated engine at medium speed & high speed.

A.DIESEL SMOKE AND CONTROL

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

B.MECHANISM OF SMOKE FORMATION

Diesel smoke originates early in the combustion process. In contrast to mixed and homogeneous fuel – air in gasoline engines, the diesel combustion chamber has different fuel – air ratios in different parts. Whenever, the fuel is burned in some localized portion of combustion chamber for fuel – air ratios corresponding to FR = 1.5 or higher and at pressures developed in diesel engine soot is produced. Table 3 shows the Emission characteristics of 4 –stroke normally aspirated engine.

The amount of the soot produced depends upon the local fuel – air ratio, type of fuel and the pressure. Normally, this soot is consumed during the latter part of the combustion. However, if the soot does not find sufficient oxygen to burn, it is exhausted and if in sufficient quantity it becomes visible and calls it as smoke.

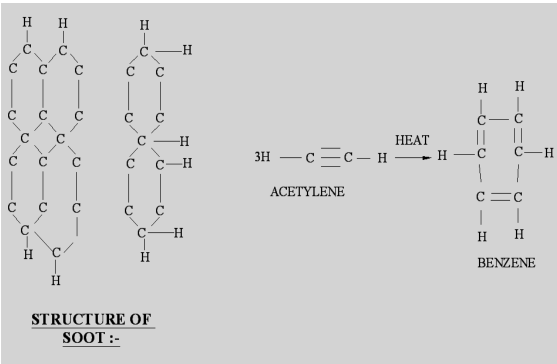

Figure 5: Structure of soot

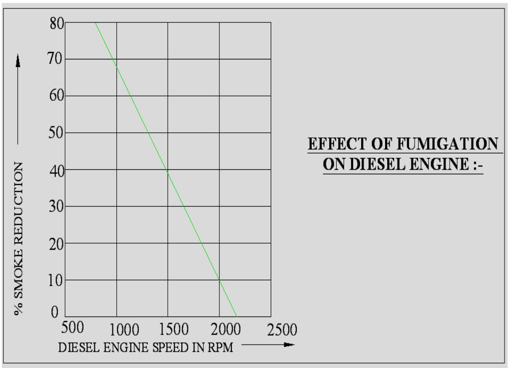

Figure 6: Effect of fumigation on diesel engine

C.MECHANISM OF SOOT FORMATION

All soots have a graphite structure with hexagonal basic carbon units forming a small crystalline atom. There is a strong suggestion that it is a poly – benezoid substance that can cause lung cancer. The structure of soot is given below. The basic reaction of soot formation is yet unknown but the following theories have been advanced.

- The reaction forming carbon monoxide ($2CO = = C + CO_2$) is strongly catalyzed by carbon. So when particles are already present in some form, they build up rapidly and then polymerize.
- According to the second theory the hydrocarbons, especially heavy ends, decompose into simple small basic units of C2 and C3 and these small radicals polymerize to form C6 ring polymers.

Soot has a free valency available, so it has tremendous agglomeration properties and can be absorbed in metal surfaces, i.e., it is a powerful absorption agent. Once it sticks to the metal it is very difficult to remove it. Fig 5 shows the Structure of soot.

D.MEASUREMENT OF SMOKE

Visual judgement of smoke levels is not possible due to light effects under varying conditions, e.g. the visual assessment depends on gas velocity and background. There are two basic types of smoke meters, which are used to measure smoke density.

1) Filter darkening type,
2) Light extinction type.

The light extinction type of meters can measure both white and black smoke while, the filter paper type meters can give only black smoke readings. The light extinction meter can be used for continuous measurements while, the filter type can be used only under steady state conditions.

i. Boschh smoke meter

Borsch smoke meter is filter darkening type. A measured volume of exhaust gas is drawn through a filter paper, which is blackened, to various degrees depending upon the amount of carbon present in the exhaust. The density of soot is measured by determining the amount of light reflected from the sooted paper the diameter of the filter paper. The diameter of the filter paper, the sample volume, etc., all is well defined.

ii. Van Brand Smoke Meter

Van Brand Smoke Meter is also filter darkening type. The exhaust sample is passed at a constant rate through a strip of filter paper moving at a preset speed. A stain is imparted to the paper. The intensity of the stain is measured by the amount of light, which passes through the filter and is an indication of the smoke of light, which passes through the filter and is an indication of the smoke density of exhaust. Bosch and Van Brand smoke meters differ in the first the amount of light reflected is the measure of smoke level while in the second amount of light passing through the filter to indicate smoke level.

iii. Hartridge smoke meter

This smoke meter works on the light extinction principal. The continuously taken exhaust sample is passed through a tube of about 46cm length which, has a light source at one end and photocell or solar cell at the other end. The amount of light passed through this smoke column is used as an indication of smoke level.

This smoke density is defined as the ratio of electric output from the photocell or solar cell when sample is passed through the column to the electric output when clean air is passes through it.

Smoke meter designed by using a three-way cock is used to pass clean air or exhaust smoke through the smoke meter column. A buffer space is provided so that smoke particles and vapor do not condense on the glass plates used. Instead of a conventional photocell, a number of solar cells are used. This makes the instrument very sensitive and accurate. The output from the solar cell is fed to a micro – voltmeter and light source is provided with control to vary the amount of light, if needed, because of any change in the tube characteristics due to prolonged used of the meter. This type of meter is useful for continuous testing and can be used in vehicle.

iv. UTAC smoke meter

This also works on the light extinction principle, but it differs from the Hartridge meter in that in this meter whole of the exhaust gas is passed through the meter to avoid any sampling error. However, this is not very suitable for large engines due to its prohibitive size. The U.S.A. Public Health Service (PHS) has also developed a similar smoke meter.

E.CONTROL OF SMOKE

The above discussions clearly indicate that the only method available to control the smoke level of a diesel engine is as follows:

- **Derating**

At lower loads the air – fuel ratio obtained will be higher and hence the smoke developed will be less as already discussed. However this means a loss of output.

- **Maintenance**

Maintaining the engine in a proper way especially the injection system will not only result in significantly reduced smoke but also keep the performance of the engine at its best. The other methods are to change in combustion chamber geometry, fumigation, and use of smoke suppressant additives

The amount of equipment required achieving a reduction in some, which will taper off at higher speeds, at which most of the time the engine will run do not make it an attractive methods of smoke control especially when other methods of smoke control, like use of additives, are available. However, the strict air pollution regulations can expedite development in this direction.

- **Smoke Suppressant Additives**

Some barium compounds if used in fuel reduce the temperature of combustion, thus avoiding the soot formation, and if formed they break it into fine particles, thus appreciably reducing smoke. However, the use of barium salts increases the deposit formation tendencies of engine and reduces the fuel filter life.

- **Catalytic mufflers**

Unlike petrol engine the use of catalytic mufflers are not very effective. There is a very small effect on engine smoke. Such devices need much development before they can be used in practice.

- **Fumigation**

Fumigation consists of introducing a small amount of fuel into the intake manifold. This starts pre – combustion reactions before and during the compression stroke resulting in reduced chemical delay because the intermediate products such as peroxides and aldehydes react more rapidly with oxygen than original hydrocarbons. This shortening of the delay period curbs thermal cracking, which is responsible for soot formation. It may even happen that cracking does not occur at all because it requires about 80 kcal/mole to beak a double bond C=C and this energy may not be available due to easy oxidation during pre – combustion reactions. The Fumigation rate of about 11 to 15 percent gives best smoke improvement. However, this improvement varies greatly with engine speed. At low engine speeds 50 to 80 percent smoke reduction is obtained. These decreases as speed increases until a speed at which there is no effect of fumigation. Fig 6 shows the Effect of fumigation on diesel engine.

F.DIESEL ODOUR FOR CONTROL

So far the problem of odor measurement has eluded all instruments or analytical procedures to evaluate it. The state of art odor measurement is still in the developing stage and will take at least a few years before some reliable method of odor measurement is evolved. The most used method is to use a human panel to decide the odor intensity. There have been some attempts by various investigators, notable Turk, to standardize this method but all these are unreliable due to many human factors, which come in the way of such evaluation. For this reason the following discussion of the odor problem is general in approach and no specific or rigid rules can be formulated regarding this. The members of the aldehyde family are supposed to be responsible for the pungent odors of diesel exhaust. Though the amount of aldehydes is small, being less than 30 ppm, the concentrations as low as 1ppm is irritating to the human eyes and nose. The objectionality of diesel exhaust odor is characterized by having intensity rating to it. A number of odor producing components like nepthaldehyde, a – butylbenzene, etc., are given standard things and a trained human panel gives odor ratings to the given exhausts sample by comparison. This standard is now in vogue because of the absence of a better method for odor evaluation. This is subject to error due to varied human response to same type of odor and other subjective factors.

VI. EMISSION ANALYSIS WITH ORSAT APPARTUS

A.APPARATUS CONSTRUCTION

The exhaust gases from the boiler may be analyzed by means of an orsat apparatus. An illustrative diagram of this apparatus is simplest form, the apparatus consists of a measuring glass tube M and three flasks E1, E2, and E3. E is a movable flask, which is connected to the bottom of the measuring tube M, through a rubber, for producing suction or pressure on the sample of the exhaust gases. Flask E1 contains a solution of caustic soda, which readily absorbs the carbon-di-oxide from the sample.

Flask E2 contains pyrogallic acid and caustic, which will absorb the oxygen from the sample.

Flask E3 contains a solution of cuprous chloride in hydrochloric acid, which will absorb the carbon monoxide.

Each of the three flask E1, E2, and E3 is provided with a stop cock C1, C2 and C3 respectively and is connected to the main tube t with a three way cock c.

The three way cock C connects the apparatus either to exhaust gases or to the atmosphere. In another position it disconnects the apparatus both from exhaust gases and atmosphere. The measuring tube M is graduated from 0 to 100 cc 'j' is an outside jacket surrounding the standard temperature. The chemicals in flask E1 and E2 are protected by extra flask, which act as water seal. Both of these chemicals absorb oxygen and, if they are exposed to the atmosphere, will soon be saturated with oxygen.

B.PROCEDURE & WORKING PRINCIPLE

To analyze a given sample of a gas, 100 cm^3 of the gas are drawn into the measuring tube m, by lowering the movable flask E. now the stop cock C1, is opened and the whole of exhaust gas is forced into the flask E1 which contains solution of caustic soda. The gas sample is allowed to stand in this flask for about 30secs to allow most of the carbon-di-oxide to be absorbed. The movable flask E is then lowered until the chemical in flask E1 rises to the original level. The volume of exhaust gas sample absorbed in this flask can be read on the scale of the measuring tube M. Water is held at the same levels in both the movable flask and the reading is taken. The exhaust gas sample is again forced into the flask E1 to make sure that whole of carbon-di-oxide in the sample has been absorbed. This process is repeated a number of times until two identical successive readings are obtained on the measuring tube.

The remainder of exhaust gas sample then forced into the flask E2 that contains pyrogallic acid and thus absorbs oxygen contour from the flue gas sample. Just as before, the sample is forced into the flask E2 a number of times to ensure complete removal of oxygen. The readings on the measuring tube will now be the sum of the percentage of carbon-di-oxide and the percentage of oxygen in the given sample. The percentage oxygen may be determined by simple subtraction. Finally, the sample is forced into the third flask E3 containing acid solution of cuprous chloride, which will absorb carbon monoxide form, the given sample. The volume of gas absorbed is again read on the measuring tube M. When the percentage of carbon-di-oxide, oxygen, and carbon monoxide are known, the remainder of the gas is assumed to be nitrogen. Since, the gas is collected over water in the measuring tube M; any steam present will be condensed. Also sulphur-di-oxide, if any will be absorbed. Here orsat apparatus gives the percentage of dry flue gases only.

SPECIFICATIONS

Scrubber Tank

- Alkaline solution - Lime Water (Ca $(OH)_2$)
- Water level from bottom - 120mm
- Chemical - Lime stone ($CaCO_3$)

Bell mouth bottom portion

Submerged in the alkaline solution - 25mm

Engine Details

- Engine - ANIL 6 HP
- Type - vertical 4 stroke

▪ Fuel	-	HSD
▪ No. of cylinder	-	One
▪ Bore Dia.	-	114.3mm
▪ Stroke	-	134.7mm
▪ Speed	-	650rpm
▪ Power	-	4.40kw
▪ Cooling system	-	Water

VII. SUGGESTIONS

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 NO_2.
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.
7. An anti-sealing compounds like neveseife (MO2) can be used to increase the life of the tank due to seasoning. (Variation in operating temperature)
8. Descaling compounds like Corroclean, which are industrially proven and commercially available, can be used for descaling the tank.

VIII. CONCLUSION

The paper has dealt about the Diesel Power Utilization in inflammable atmospheres and their effects on such environment. Simple methods for reducing the obnoxious particulate of the Diesel 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 going through the Diesel Emission Analysis by Orsat Apparatus, 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 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.

6. Nitrogen Oxide (NO) is converted into No2 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 SO2 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 diesel smoke is reduced. Diesel 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 diesel smoke is reduced when water scrubbers are used.
9. Water is used to absorb heat from the diesel exhaust so that the temperature of the surroundings is reduced while using scrubber tank. After scrubbing the diesel 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 Diesel Emission (0.20% by volume) does not pose any health, when compared to Gasoline engines.

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