Fabrication of Catalytic Convertor for Automibile

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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 toxic 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. The rapid growth in the energy consumption at the individual level has given rise to a dramatic increase in both air and water pollution problems. The automobile is probably the most notorious source of atmospheric air pollution on a total mass basis. Under the Indian Conditions two and four wheelers have become the most popular mode of transport. In the present work catalytic converter was chosen for CI engine emission control, to reduce CO, HC and NOx emission. A catalytic converter has to be designed and introduced in the exhaust line of the CI engine. In the present work Kirloskar TV-I engine is chosen for emission control study using a catalytic converter. The objective of the catalytic converter is to reduce the cold start emission of CO, HC and NOx in the exhaust gas of the engine. The catalytic converter is made of stainless steel plate. The plate is coated with copper, Nickel and Chromium catalytic materials. These emission levels will be measured using the AVL exhaust gas analyzer and the results will be analyzed.**

***Index Terms*— catalytic converter, Kirloskar TV-I engine, Diesel fuel, exhaust particulates and Ceramic foams.**

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. In spite; 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.

A.Reduction of obnoxious exhaust particulates

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 – 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.

B. Measurement of exhaust gas content analysis and control

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 of 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.

Heterogeneous catalysis lies at the heart of most conversion processes in oil refining, and in petrochemicals manufacture, natural gas conversion, and environmental processes. The catalysts typically used are porous inorganic solids, with or without added metals. Catalyst shaping is an important issue, with a need to balance performance, strength, and pressure drop across the catalyst system. Many catalysts are used as randomly packed fixed beds of small particles (e.g. extrudates, granules or spheres), typically in the millimeter size range. Monolithic structures, which consist of large single catalytic entities, are attracting increasing attention, and recent progress is reviewed in this article. Two types of monolithic catalyst are discussed: honeycombs, which are made in very large numbers as carriers for automotive exhaust catalysts, and the much newer ceramic foams. The term monolith is sometimes regarded as being synonymous with

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honeycomb, but we suggest that monolith more appropriately refers to any catalyst bed which is a single entity.

In addition, the fabrication techniques used to produce honeycombs and reticulated ceramics are becoming progressively more complex and at the same time better controlled. This brief review will focus on recent advances in ceramic catalyst carriers and their advantages with respect to mechanical, thermal, and chemical stability. New candidate materials for catalyst supports will also be discussed.

Ceramic foams, sometimes referred to as reticulated ceramics, are three-dimensional cellular structures in which the cells are connected by open windows, giving high porosity of the order of 80-90% void space. These materials have been developed, mainly in the past decade, to filter out impurities from molten metals. In the past two years, interest in these materials as catalyst carriers has expanded considerably. Ceramic foams possess certain advantages compared with the honeycombs: a much wider range of shapes are available due to the method of preparation discussed below; the more tortuous nature of the porosity which improves reactant mixing and favors

C.Exhaust of back pressure and engine performance

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 lie anywhere between 500°c to 700°c.

The pressure of the exhaust gas depend upon so many factors viz.,

- The design of exhaust gas manifold
- Magnitude of valve overlap
- 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 to 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 fuels consumption rate and so the combustion characteristics of an engine is 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.

Considering the factors to the specific application of this project, introductions of a scrubber tank will definitely increase the back pressure. In the scrubber Tank the followings are the factors which will contribute to the increase of back pressure.

II. CONSTRUCTIONAL FEATURES

A. Outlet pipe from the engine or inlet to the scrubber tank

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.

B. Scrubber-tank assembly

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.

C.Tank fabrication

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 process 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.

D.Bell – Mouth Fabrication

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.

E.Lime stone Container Fabrication

The container is made of standard steel plates, which has 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. This facilitates the easy flow of exhaust gas, because the effective area is more than 1.5 times the area at the inlet of bell – mouth.

F.Level plug cum drains

The level plug cum drain is fabricated using 12.7mm nominal bore pipes fittings and conforming to BIS: 1369 Where, fabricated using electric arc welding. The surface is rough ground in order to have 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.

G.Headers

Switching from an exhaust manifold to exhaust headers (also known as extractors in Australia) will optimize the exhaust gas flow speed and in turn increase the high-end power of the engine. This is done by using an individual pipe for each exhaust port that has smoother bends with a larger turn radius, decreasing airflow resistance, as well as a calculated pipe diameter to obtain a good scavenging effect for the specific engine capacity. The pipes then merge into a collector and then flow into a larger pipe (down pipe), just before the catalytic converter. With equal length headers, as each exhaust valve in the head of the engine is opened and exhaust gas is forced out, it passes down one of the header pipes and through to the down pipe, where the exhaust gas velocity causes a slight vacuum in another header pipe. Figure 1 Shows the header.

Figure 1: Header arrangement

III. CATALYTIC CONVERTER

Catalytic converters are necessary to reduce emissions but create back pressure due to the exhaust gases being forced through a catalyst, and therefore decrease high-end engine power. Many modern catalytic converters only produce 1-3 psi of back pressure, though this restriction worsens further with use. Hi-flow catalytic converters can replace the standard units in order to provide lower backpressure. Installing aftermarket catalytic converters is restricted by law in some countries, with bolt-on straight 'test pipes' available to test whether a clogged catalytic converter is causing problems, which can be easily swapped out for on-road use or scheduled emissions testing. Hollowing out a catalytic converter is unlikely to give power gains unless a pipe is placed through the converter to give a clear path for exhaust gasses.

A catalytic converter (colloquially, "cat" or "catcon") is a device used to reduce the toxicity of emissions from an internal combustion engine. Catalytic converters are also used on generator sets, forklifts, mining equipment, trucks, buses, trains, and other engine-equipped machines. A catalytic converter provides an environment for a chemical reaction wherein toxic combustion by-products are converted to less-toxic substances.

A.Construction

The catalytic converter consists of several components:

a) The core or substrate. The core is often a ceramic honeycomb in modern catalytic converters, but stainless steel foil honeycombs are used, too. The honey-comb surface increases the amount of surface area available to support the catalyst, and therefore is often called a "catalyst support".

b) The wash coat. A wash coat is used to make converters more efficient, often as a mixture of silica and alumina. The wash coat, when added to the core, forms a rough, irregular surface, which has a far greater surface area than the flat core surfaces do, which then gives

c) The converter cores a larger surface area, and therefore more places for active precious metal sites. The catalyst is added to the wash coat (in suspension) before being applied to the core.

The catalyst itself is most often a precious metal. Platinum is the most active catalyst and is widely used. It is not suitable for all applications, however, because of unwanted additional reactions and/or cost. Palladium and rhodium are two other precious metals used. Platinum and rhodium are used as a reduction catalyst, while platinum and palladium are used as an oxidization catalyst. Figure 3.2 shows the Construction of catalytic converter.

B.Types of Catalytic converter

- **Two-way**

A two-way catalytic converter has two simultaneous tasks:

1. Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 — 2CO_2$

2. Oxidation of unburnt hydrocarbons (unburnt and partially-burnt fuel) to carbon dioxide and water: $C_xH_{2x+2} + 2xO_2 — xCO_2 + 2xH_2O$ (a combustion reaction)

This type of catalytic converter is widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions.

- **Three-way**

Since 1981, three-way catalytic converters have been used in vehicle emission control systems in North

America and many other countries on road going vehicles. A three-way catalytic converter has three simultaneous tasks:

1. Reduction of nitrogen oxides to nitrogen and oxygen: $2NO_x \rightarrow xO_2 + N_2$

2. Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 \rightarrow 2CO_2$

3. Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water:

$$C_xH_{2x+2} + 2xO_2 \rightarrow xCO_2 + 2xH_2O$$

These three reactions occur most efficiently when the catalytic converter receives exhaust from an engine running slightly above the stoichiometric point. This is between 14.6 and 14.8 parts air to 1 part fuel, by weight, for gasoline. The ratio for LPG, natural gas and ethanol fuels is slightly different, requiring modified fuel system settings when using those fuels. Generally, engines fitted with 3-way catalytic converters are equipped with a computerized closed-loop feedback fuel injection system employing one or more oxygen sensors, though early in the deployment of 3-way converters, carburetors equipped for feedback mixture control were used. While a 3-way catalyst can be used in an open-loop system, NOx reduction efficiency is low. Within a narrow fuel/air ratio band surrounding stoichiometry, conversion of all three pollutants is nearly complete. However, outside of that band, conversion efficiency falls off very rapidly. When there is more oxygen than required, then the system is said to be running lean, and the system is in oxidizing condition. In that case, the converter's two oxidizing reactions (oxidation of CO and hydrocarbons) are favored, at the expense of the reducing reaction. When there is excessive fuel, then the engine is running rich.

Monolithic Catalytic Converter: Catalytic converter with a catalyst-coated, ceramic honeycomb monolith (monolith is a large block of stone or anything that resembles one in appearance, intractability, etc) through which the exhaust gases pass. Predominately the catalytic converter contains a palladium-impregnated ceramic honeycomb monolith then a platinum and rhodium-impregnated ceramic honeycomb monolith. The exhaust gas flow contacts the palladium-impregnated monolith then contacts the platinum and rhodium-impregnated monolith. The operating temperature of a cat is between 350 to 400 degrees Celsius which causes a chemical reaction to occur as the exhaust gases flow through the coated monolith. The harmful gases are oxidized and converted. Monolithic-type catalytic converters have mostly replaced pellet converters.

- Gasoline Catalytic Converters
- Diesel Catalytic Converters
- Pellet (Ceramic Bead) Type
- Monolith (Honeycomb) Type
- Two-Way
- Three-Way
- Three-Way + Air

Pellet Catalytic Converter: Pellet Converter's contain a beaded type or pellet catalyst material. Introduced in the USA in 1975, the Pellet-type catalytic converter was the first type of automotive catalytic converter. It consisted basically of a sheet steel catalyst container surrounded by thermal insulation and a sheet steel outer shell. The catalyst container was fitted with one or two beds of ceramic pebbles (pellets) coated with a catalyst. This type of catalytic converter suffered from poor service life due to vibration-induced attrition of the catalytic coating; this also produced additional particulate emissions and the pellet bed caused high exhaust back pressure, resulting in poor engine performance. Pellet-type catalytic converters have been superseded by monolithic converters. Figure 2 shows the different types of converters. Figure 3 shows the thermal insulation of catalytic convertor.

Figure 2: Monolithic converters

Figure 3: Thermal insulation of catalytic converter

4.16. Anatomy of Catalytic Converter

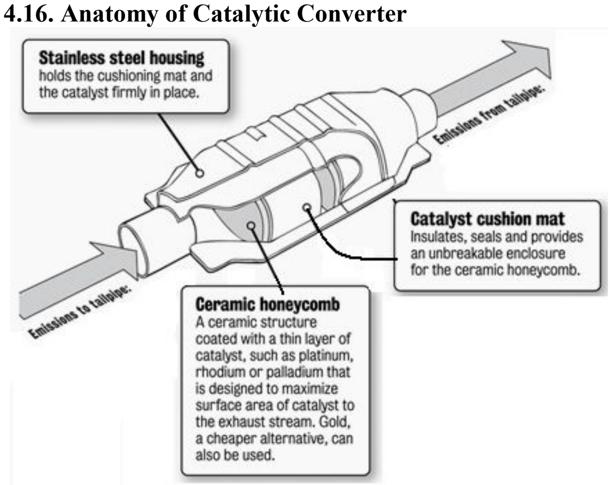

Figure 4: Anatomy of Catalytic Converter

The catalytic converter assembly consists most of these components, inlet/outlet pipes/flanges, steel housing, insulation material, seals, inlet/outlet cones, substrate(s), coating and sensor boss. Figure 4 shows the anatomy of Catalytic Converter.

- A steel housing provides protection and structure support for substrate; insulation material (mat or wire mesh) provides heat insulation and support between steel housing and substrate; seals are there to protect mat material from been burned by the exhaust gas.
- The ***substrate*** is often called a "catalyst support". It is a ceramic honeycomb or a stainless steel foil honeycomb in modern catalytic converters. The ceramic substrate was invented by Rodney Bagley, Irwin Lachman and Ronald Lewis at **Corning**, in use to increases the amount of surface area available to support the catalyst.
- The ***wash coat*** is used to make converters more efficient, often as a mixture of silica and alumina. When a wash coat is added to the substrate, it forms a rough, irregular surface, which has a far greater surface area than the flat core surfaces do, which then gives the Substrate a larger surface area, providing more sites for active precious metal – the catalytic which is added to the wash coat (in suspension) before being applied to the substrate.
- The ***catalyst*** itself is most often a precious metal. Platinum is the most active catalyst and is widely used. However, because of unwanted additional reactions and/or cost, Palladium and Rhodiums are two other precious metals that are used. Platinum and rhodium are used as a reduction catalyst, while platinum and palladium are used as an oxidization catalyst.

C.Gasoline Engine Application

On a global basis, most passenger cars are equipped with stoichiometric Otto engines. Although the exhaust gas after-treatment for such type of engines is well-known, the three-way converter (TWC) has been the primary emission control technology on light-duty gasoline vehicles since the early 1980s. The use of TWCs, in conjunction with the oxygen sensor-based, closed-loop fuel delivery system, allows for simultaneous conversion of the three criteria pollutants, HC, CO, and NOx, produced during the combustion of fuel in a spark-ignited engine. Three-way catalysts are one essential part of this system design. In gasoline catalytic converter application, the active catalytic materials are present as a thin coating of precious metal (Pt, Pd, & Rh), and oxide-based inorganic promoters and support materials on the internal walls of the honeycomb substrate. Figure 5 shows the Three-way converter (TWC).

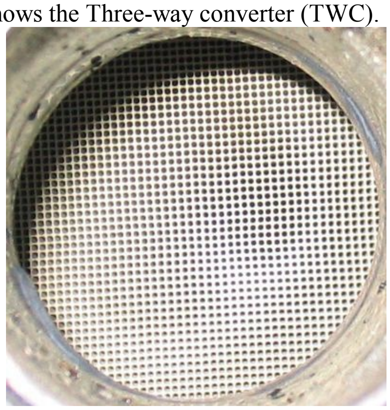

Figure 5: Three-way converters (TWC)

D.For petrol engines

As well as its silencing and evacuation functions, the exhaust pipe is now used to treat exhaust gases**.** Engine exhaust gas is charged with carbon monoxide (CO) and nitrogen oxides (NOx), particularly dangerous gases that the catalytic converter manages to eliminate by almost 99%. Similarly, the very high temperature required for its operation inside the porous structures, performs "post-combustion" of unburned hydrocarbons.

The ideal concentration for full efficiency of catalysis is 1 gram of fuel to 14.7 grams of air.

Figure 6: Two way catalytic converter

Current two-way catalytic converters eliminate toxic components from exhaust gases in two almost simultaneous steps - the first eliminates carbon monoxide and the second deals with the nitrogen oxides (NOx). These two elements are comprised of a honeycomb structure made of ceramic to be able to resist the very high temperatures essential for catalysis. One of the elements is placed close to the engine to rapidly reach the temperature and deal with pollutant emissions as rapidly as possible. Finally, although the catalytic converter improves air quality by eliminating toxic exhaust gases, it cannot prevent the formation of carbon dioxide. For this reason, other means must be used to reduce emissions of this greenhouse gas. Figure 6 shows the two way catalytic converter.

E. Catalyst selection criteria

The selection of catalytic convertors can be broadly classified into the following:

a. Engine Displacement
b. Gross Vehicle Weight
c. Non-EGR engines (Special Needs)
d. High performance/high compression applications (Special Needs)
e. Air Injection (Special Needs)
f. Low power to weight ratio (Special Needs)
g. OBDII (Special Needs)

F. Design of Catalytic Convertor

The important parameter to be considered in the design of catalytic converter is the volume of the converter. The design criteria for fixing the volume of the converter are space velocity which is defined as follows:

The reciprocal of the space velocity will be the residence time generally the rage of space velocity is 15000 to 100000 h- 1. An average space velocity suitable for the engine is to be selected. At the maximum load and rated speed, the mass flow rate of air (ma) entering the engine is determined by using an orifice meter and the mass flow rate of the fuel (mf) is determined by noting the time for the consumption of known volume of fuel using a burette fitted to the fuel tank. The sum of these two (Ma + mf), gives the mass flow rate of the exhaust gas, which is converted into volume flow rate by dividing it by the density of exhaust gas. Figure 7 and 8 shows the Cu coated plate and Cr coated plated.

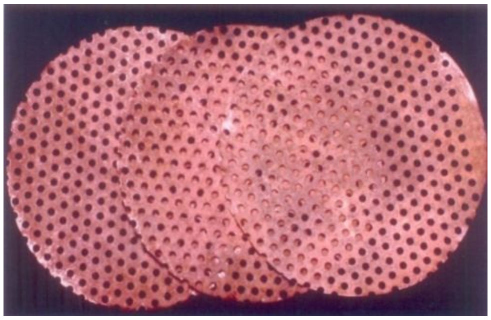

Figure 7: Cu coated plate

For the engine considered in this study, the maximum volume flow rate of exhaust gas was found to be 140.66/40000 hr-1 was selected. Hence the converter volume was obtained as 140.66/40000 = 3516 cm^3. Choosing an axial flow, single bed converter of circular cross section, a bed diameter of 122 mm and bed length of 300 mm were selected for the converter. Mild steel plate of 1.2 mm thickness was used to fabricate the catalytic converter.

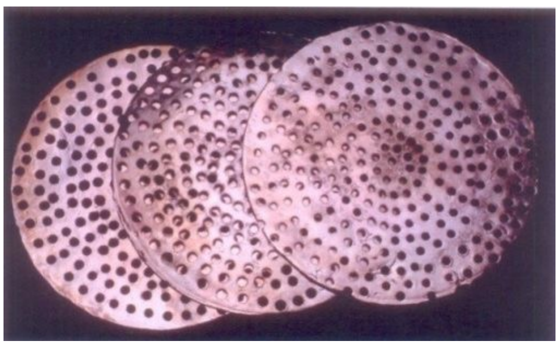

Figure 8: Cr coated plate

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 at 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. Figure 9 shows the Catalytic converter.

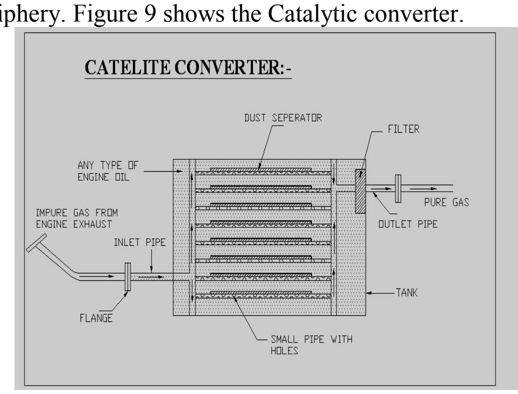

Figure 9: Catalytic converter

IV. 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. Table 1 shows the range of concentration of different constituents of diesel exhaust. Engine type and the mode of operation are two main factors, which influence the exhaust emissions from a diesel engine.

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

A. Methodology

Electric heated catalytic converter is reducing the cold start exhaust emission. The easiest way to preheat the converter is to use of electrical heater plug. Three number of 15 Ams heater plug should be used in catalytic converter. Two heater plugs are provided before converter bed one heater plug was placed after Catalytic converter. Before starting the engine the catalytic converter bed should be preheated by using 12V battery supply through the heater plug. The effect of heating reduces the CO and HC emissions the results are compared with and without heating of catalytic converter.

B. Experimental procedure

- Check the fuel level in fuel tank
- Before starting the engine, heat the plates inside catalyst converter to 50°C with the help of heater plugs.
- Start the engine properly
- catalytic converter was provided, with chromium coated MS plates, copper coated MS plates and Nickel coated MS plates for three trials
- Take the fuel consumption for 3 minutes with the help of stop watch and level indicator in the fuel tank
- With help of AVL di-gas analyser, CO, CO2, HC and NOx were measured before and after catalytic converter. AVL di-gas analyser is shown in figure 10.
- Take the exhaust temperature before and after catalytic converter.
- Repeat the above procedure for 1800, 2200, 2600 and 3000 rpm and the readings are tabulated.
- The above procedure is taken for three trials.

Figure 10: Photographic view of AVL di-gas analyzer

V. Experimental set-up

Experimental investigation was carried out on Kirloskar TV-1 diesel engines. Catalytic converter was designed, fabricated and introduced in the exhaust line of the engine. The catalytic converter housing is made of stainless steel. The sectional view of catalytic converter is shown in figure 11. Exhaust gas analyzer (NDIR) was used to measure the CO, HC and NOx emissions. The bed temperature was measured by digital thermometer using thermocouple. The engine was run at constant brake power by varying the speed. The emission concentrations of HC, CO, NOx and fuel consumption were noted. Before starting the engine the heater is switched on for the purpose of raising the bed temperature. When the bed temperature reaches 60°C the electrical unit automatically disconnected the power source. The heating arrangement lowers the cold start emission and improves the life of the converter. The temperature is an important parameter for better chemical reaction. The concentrations of CO, HC and NOx were measured before and after the catalytic converter for different speed conditions. The conversion efficiency of the catalytic converter at different speed was determined using the expression.

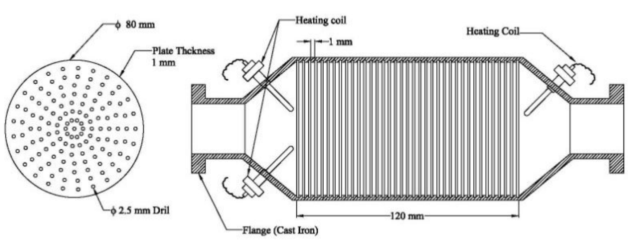

Figure 11: Sectional view of catalytic Converter

VI. RESULTS AND DISCUSSIONS

Figure 19 shows the variation of CO emission with different speed of the engine without heating the catalytic converter. Without catalytic converter (WOCC) the CO emissions are varying from 6.3% by volume at 1400 rpm to by 4.89% by volume at 3000 rpm. By using Cu coated catalytic converter 2.75% by volume of CO emission decreases at 1400 rpm. At higher speed CO emission further reduced 3.4% by volume. This is due to high bed temperature of the catalytic converter. Among the catalytic materials used in the converter the Nickel coated catalytic converter shows maximum reduction of CO emission. In the Nickel coated catalytic converter 3.9% CO reduction achieved at 1400 rpm.

Figure 12 shows the CO emission with varying speed of the engine with catalytic converter (WCC). Without catalytic converter CO emission varies from 6.3% by volume at 1400 rpm to is 4.89% by volume at 3000 rpm.Due to heating of the catalytic converter the bed temperature rises about 60°C the faster light off temperature take place. It is found from the graph due to electrical heating maximum reduction of emission for all the catalytic converter. Figure 13.shows the CO_2 against engine Load (With catalytic convertor). Figure 20 .shows the CO_2 against engine Load (Without catalytic convertor).Figure 14 shows the O_2 against engine Load (With catalytic convertor)

Figure 21 shows the variation of exhaust gas temperature with varying speed of the engine without heating of the catalytic converter. At 1400 rpm the exhaust gas temperature is 450°C without catalytic converter and 580°C at 3000rpm. The effect of catalytic converter Copper, Chromium and Nickel the exhaust gas temperature is 430°C, 400°C and 380°C respectively at various speed conditions. Among the catalytic materials there are no appreciable changes in exhaust gas temperature at maximum speed of the engine. Similarly with the heating of catalytic converter marginal changes in exhaust gas temperature is shown in figure 18.

The variation of HC emission without heating the catalytic converter with different speed of the engine. The HC emission gradually decreases when the engine speed increases for all the cases. Among the three catalytic converters the Copper coated converter shows maximum reduction of HC emission about 300 ppm. The reason is the Copper coated catalytic converter having higher oxygen reaction that leads to faster oxidation process. The figure 15 shows variation of HC emission with heating the catalytic converter for different catalytic materials. The HC level varies from 500 ppm at 1400 rpm to 300 ppm at during maximum speed of the engine without catalytic converter. With heating the use of catalytic converter at lower speeds faster light off temperature achieved. Figure 23shows the Smoke density against engine Load (Without catalytic convertor).

Hence the HC emission significantly reduced for heating of catalytic converter. Figure 22 shows the NOx emission with different engine speed with different coated materials without heating. At lower speed NOx emission is 550 ppm and gradually increases at part speed and beyond that the emission level gradually decreases. For all the catalytic converters the NOx emission significantly reduced. The Copper coated catalytic converter reduces the maximum level of NOx emission than other materials.Figure 16 shows the NOx against engine Load (With catalytic convertor). Figure 17 shows the Smoke density against engine Load (With catalytic convertor).

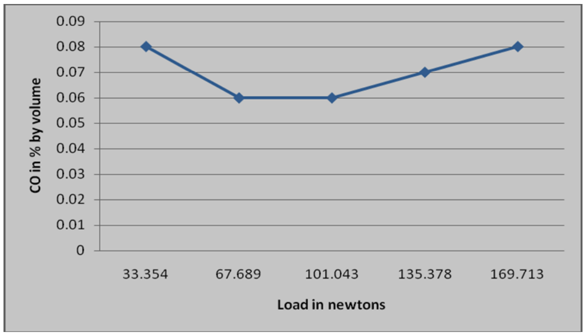

Figure 12: CO against engine speed Load (With catalytic convertor)

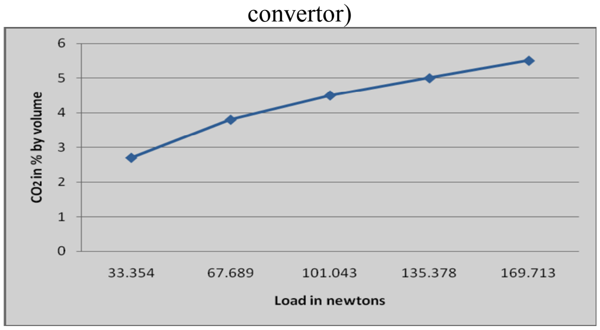

Figure 13: CO_2 against engine Load (With catalytic convertor)

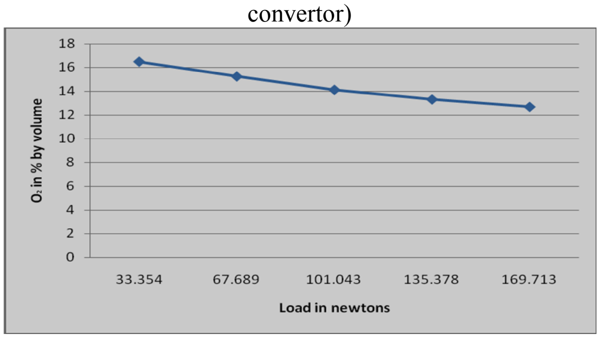

Figure 14: O_2 against engine Load (With catalytic convertor)

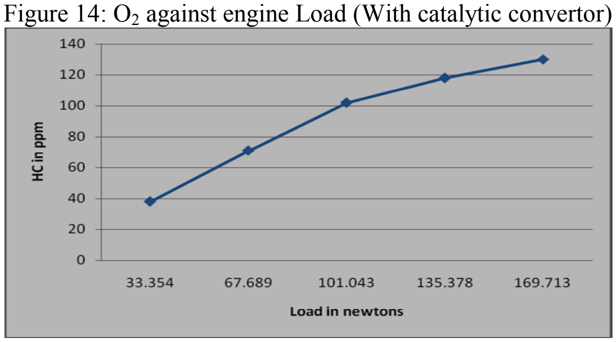

Figure 15: HC against engine Load (With catalytic convertor)

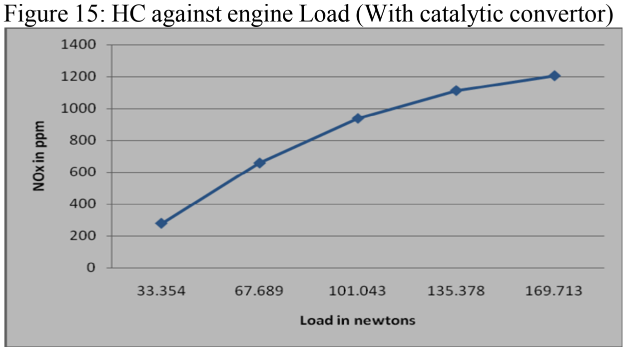

Figure 16: NOx against engine Load (With catalytic convertor)

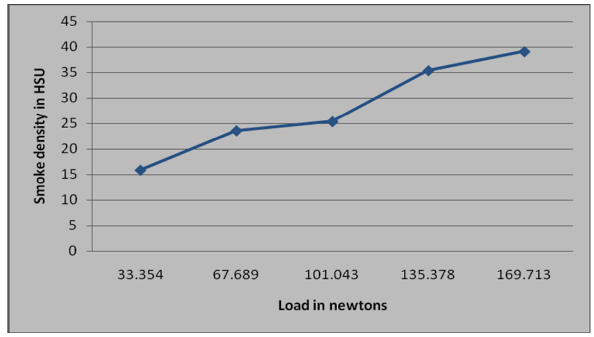

Figure 17: Smoke density against engine Load (With catalytic convertor)

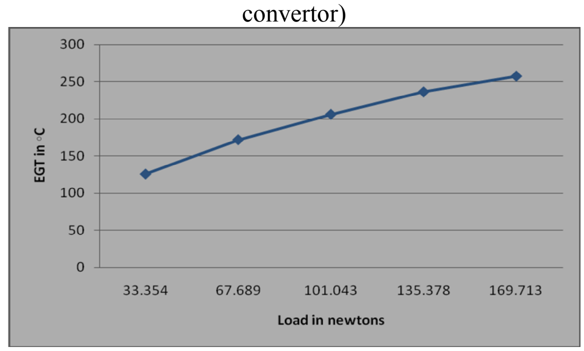

Figure 18: EGT against engine Load (With catalytic convertor)

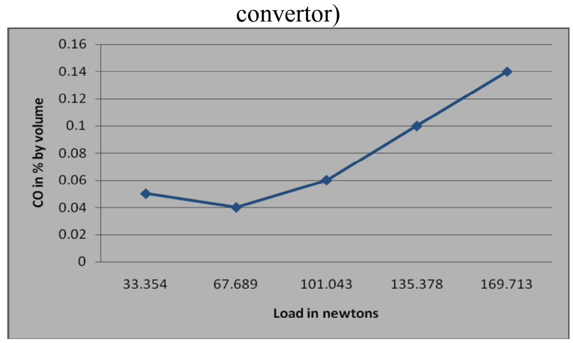

Figure 19: CO against engine Load (Without catalytic convertor)

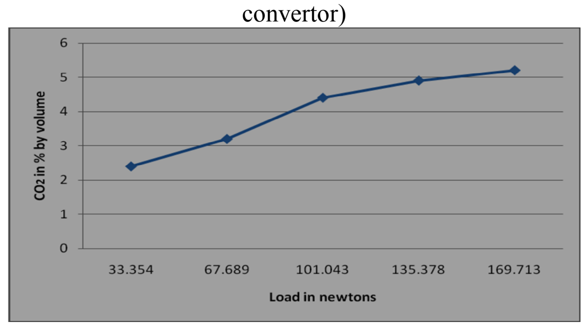

Figure 20: CO_2 against engine Load (Without catalytic convertor)

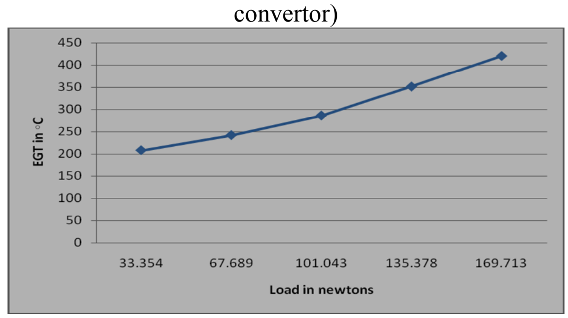

Figure 21: EGT against engine Load (Without catalytic convertor)

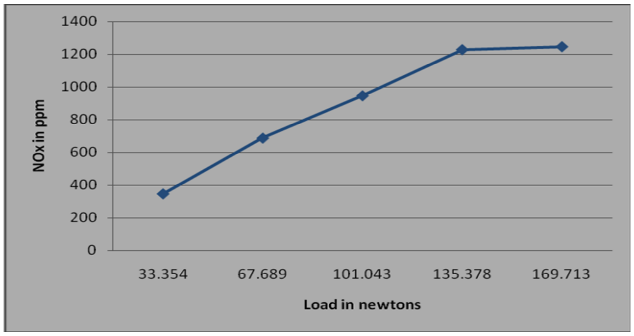

Figure 22: NOx against engine Load (Without catalytic convertor

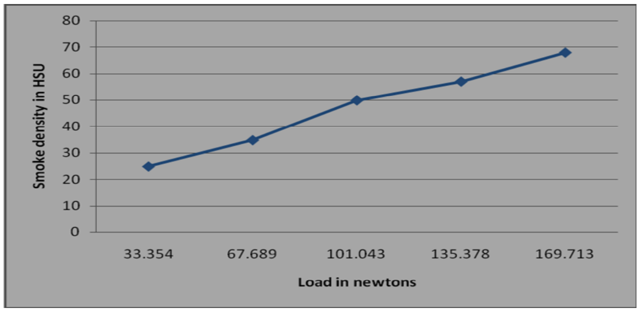

Figure 23: Smoke density against engine Load (Without catalytic convertor)

SUGGESTIONS

- 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 water level inside the scrubber due to evaporation.

- To reduce the surface temperature of the exhaust gas pipe, asbestos rope could be coiled over, so that there may not be direct contact surface with the inflammable atmosphere around.

- 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.

- After 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.

- 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.

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

- Anti-sealing compounds like neveseife (MO2) can be used to increase the life of the tank due to seasoning. (Variation in operating temperature)

- Descaling compounds like Corroclean, which are industrially proven and commercially available, can be used for descaling the tank.

VII. CONCLUSION

From the experimental investigations following observation were made

a) The experiments are conducted with varying speed with constant load by using different materials i.e. Copper, Nickel and Chromium coated plates.
b) There is marginal reduction of CO emission from copper and Chromium catalytic material without heating.
c) Using copper as catalytic converter HC emission gradually reduces when compared to other materials.
d) NOx emissions from copper coated catalytic materials have lower NOx emission when compared to Chromium and Nickel.
e) By using copper as a catalytic material with heating having less CO emission
f) By using copper as a catalytic material with heating having less HC emission
g) By using copper as a catalytic material with heating having less NOx emission

From this study dealt with 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 study, and after going through the Diesel Emission Analysis by Orsat Apparatus, with due considerations the following conclusions are derived.

- Water in the scrubber tank can itself play an important role in absorbing the obnoxious products of combustion like the oxides of Nitrogen.

- 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.

- In place of water, a weak lime solution could be used and this change will allow for the chemical reaction to take place in a faster pace.

- All the gases present in the Diesel Exhaust except the Carbon Monoxide is readily with the working media namely the limewater and Calcium Carbonate.

- 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.

- Nitrogen Oxide (NO) is converted into No2 after emission, which is highly toxic is mainly absorbed in the water scrubber.

- 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.

- 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.

- 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.

- 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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