



EXHAUST GAS ANALYSIS OF COMBUSTION IGNITION ENGINE BY USING CHEMICAL COATED WIRE MESH CATALYTIC CONVERTER

H.G. Sagar¹

¹Mechanical Engineering Department, Tolani Foundation Gandhidham Polytechnic - Adipur

Abstract-- An Exhaust emission is much concern about the Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NO_x) from the automotive vehicles. This paper presents characteristics of a catalytic converter to be used for four stroke four cylinder diesel engines. Catalytic converter with different catalyst for diesel engine to reduce pollute gases is chosen for present work. The emphasis is given on hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen. The wire mesh is developed as catalyst the wire mesh is coated with zirconium dioxide (ZrO₂). The catalyst materials are inexpensive in comparison with conventional catalysts (noble metals) such as palladium or platinum. Catalytic converter oxidizes harmful CO and HC emission to CO₂ and H₂O in the exhaust system and thus the emission in the automobile vehicle is controlled. Emission of HC, CO and CO₂ was measured and monitored for conventional OEM catalytic converter system with ZrO₂ coated wire mesh catalytic converter system. Performance of catalytic converter is depends upon temperature. Optimized temperature was found for ZrO₂ coated wire mesh catalytic converter for best performance. Effect of wire mesh on break specific fuel consumption and brake thermal efficiency were recorded and analyzed. The back pressure of the exhaust gases is measured by putting different number of wire mesh in the catalytic.

Keywords: Exhaust gas analysis, CI engine, Zirconium dioxide, catalytic converter, wire mesh

I. INTRODUCTION

There is incomplete combustion of the fuel and this leads to emissions of the partial oxidation product, carbon monoxide (CO), and a wide range of volatile organic compounds (VOC), including hydrocarbons (HC), aromatics and oxygenated species. These emissions are particularly high during both idling and deceleration, when insufficient air is taken in for complete combustion to occur.

In internal combustion engines, the time available for combustion is limited by the engine's cycle to just a few milliseconds. There is incomplete combustion of the fuel and this leads to emissions of the partial oxidation product, carbon monoxide (CO), oxides of nitrogen (NO_x) and a wide range of volatile organic compounds (VOC), including hydrocarbons (HC), aromatics and oxygenated species. These emissions are particularly high during both idling and deceleration, when insufficient air is taken in for complete combustion to occur. Carbon monoxide is a product of a partial combustion of hydrocarbons in fuel^[1].

In chemistry, a catalyst is a substance that causes or accelerates a chemical reaction without itself being affected. Catalysts participate in the reactions, but are neither reactants nor products of the reaction. A catalytic converter reduces temperature at which CO & HC convert into CO₂ and H₂O. Generally catalytic converters uses platinum group of noble metals.

II. Working of Catalytic Converter

In the catalytic converter, there are two different types of catalyst at work, a reduction catalyst and an oxidation catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream.

The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NO_x emissions. When an NO or NO₂ molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O₂. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N₂.

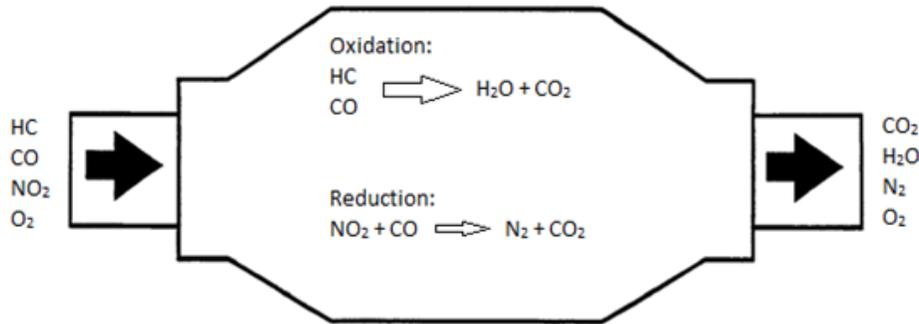
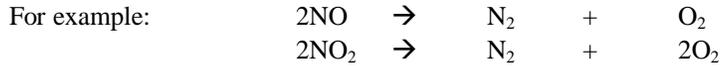
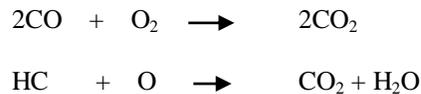


Fig.1 Chemical Reaction in Catalytic Converter

The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:



There are two main types of structures used in catalytic converters -- honeycomb and ceramic beads. Most cars today use a honeycomb structure.

III. Objective of the Work

1. To investigate and understand the phenomena of zirconium oxide in wire-mesh structure by replacing platinum, palladium and rhodium.
2. To carry out Emission test of diesel engine by replacing honeycomb structure by using wire-mesh structure.

IV. Summary of reviewed Literature

The combination of the cerium oxide and zirconium dioxide is most effective in the catalytic converter by reducing the HC, CO, and NO_x reduction as 65%, 62%, and 59% by conversion efficiency as compared to the diesel engine without CATCO.

1. The ZrO₂ gives higher strength and anticorrosion resistance to catalytic converter.^[2]
2. The catalyst combination (Cu/CeO₂/ZrO₂ + (Ag/CeO₂/ZrO₂) gives maximum back pressure (78 -290 mbar).^[3]
3. The catalyst combination (Cu/Ag/CeO₂/ZrO₂) gives minimum back pressure (46 -148 mbar) so the zirconium should use for the minimum back pressure.^[4]
4. The contact surface area is increased so the conversion efficiency of CO and HC should be higher in wire mesh structure.^[5]

V. Problem Definition

The major worry now a day in the automobile vehicle is engine efficiency and exhaust emission. There are many alternates for reducing the exhaust emission like catalytic converter, exhaust gas recirculation and positive crankcase ventilation system. Different devices developed for exhaust emissions includes thermal converters or reactors, traps or filters for particulate matters and catalytic converters. The catalytic converter found most effective after treatment for reducing engine emission in the most automobiles and other modern engines of medium or large size. It is basically a chemical chamber mounted in the flow system from the exhaust gases pass. This chamber contains catalyst and it is intended to convert harmful combustion gases by products from an engine cylinder into harmless products. In a recent era of catalytic material the rate of chemical reaction increases because catalyst helps to oxidize the material at the low oxidation temperature level. The catalytic converter oxidizes harmful CO and HC emission to CO₂ and H₂O in the exhaust system and thus the

emission is controlled in the automobile vehicle. Generally the Catalytic converter uses high cost metals such as platinum, palladium and rhodium as catalyst. Generally, catalytic converters are called as three way converter because they are used to reduce the concentration of three emission gases CO, HC and NO_x in the exhaust.

VI. Specification Of Engine Used For Experiment

Various specification of engine used for practical is shown in table 3.1 maximum power output is 100 hp, compression ratio 16:1, capacity of engine is 1995 cc. This engine is coupled with the hydraulic dynamometer.

Table 3.1 Specification of test engine

Parameter	Specification
Make	HM Diesel engine
Power	100 hp
Speed	1500 RPM
Cooling	Water Cooled
Dynamometer	Hydraulic dynamometer
No. Of cylinder	four cylinder engine
Bore × Stroke	84 × 90 (mm)
Compression ratio	16:1
Capacity	1995CC

VII. Fabrication Of New ZrO₂ Wire Mesh Catalytic Converter

Case of new catalytic converter is fabricated from the sheet of the mild steel by welding process. Honeycomb structure of catalyst was replaced by the no. of wire meshes as shown in figure. Wire mesh wash plasma coated with zirconium dioxide. 40 wire mesh coated with ZrO₂ were placed inside the catalytic converter body and 2 pieces of body was bolted to each other. This new catalytic converter was placed in between the exhaust manifold and silencer.

VIII. Result and analysis

Data recorded during the testing process are used calculation for different performance paramaters like Brake power, fuel consumption and brake thermal efficiency. CO, HC and CO₂ Concentration are also compared with base data . Detailed analysis for results of performance parameters are discussed in this chapter.

8.1 Effect of Brake Power on CO Reduction

It can be seen from fig.2, that during no load condition or starting of engine carbon monoxide contents are highest in the exhaust because during starting of engine rich air-fuel ratio is supplied to the engine and also due to incomplete combustion of fuel. When the air-fuel mixture is too rich there is insufficient air for complete combustion and some the fuel will not be burnt or at least only partially burnt. Since hydrogen has a greater affinity for oxygen, hydrogen will take all the oxygen it needs leaving the carbon with a deficiency of oxygen. As a result of the shortage of oxygen a percentage of carbon will be converted to carbon monoxide.

As load on engine increases, more amount of air is supplied compared to fuel. The air-fuel ratio becomes lean and hence amount of carbon monoxide reduces due proper combustion of fuel. Again as load on engine increases fuel consumption also increases which can be seen in fig.2. From fig.2 it can be seen that carbon monoxide contents are highest while catalytic converter is not mounted on the engine. Carbon monoxide content reduces by 75% at highest load applied, when zirconium dioxide based catalytic converter and OEM catalytic converter is attached to the engine.

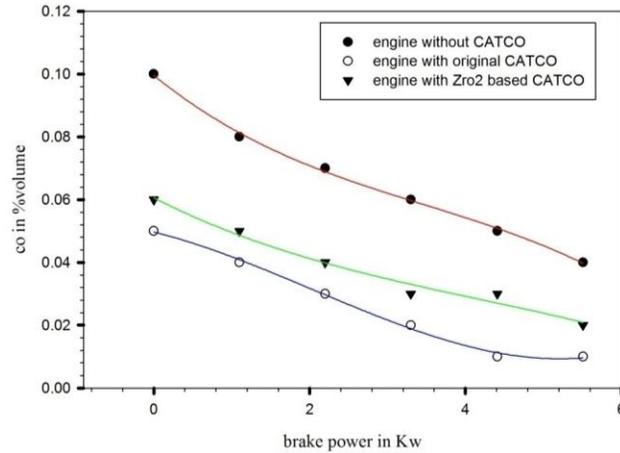


Fig.2 Brake Power VS CO

8.2 Effect of Brake Power on HC

In Fig.3, it can be seen that as brake power of engine increases, hydrocarbon content increases because of increase in fuel consumption. Generally, hydrocarbon produces due to incomplete combustion. Due to existence of local very rich mixture pockets at lower temperature than the combustion chamber, unburnt hydrocarbons will appear in the exhaust. The hydrocarbons also appear due to flame quenching near the metallic walls. Hydrocarbon contents are highest while diesel was used as fuel and catalytic converter is not mounted on the engine. Hydrocarbon content reduces by 35% at higher load, when zirconium dioxide based catalytic converter is attached on the engine. Again, 45% of HC reduction was noted at higher load when OEM catalytic converter is mounted on the engine.

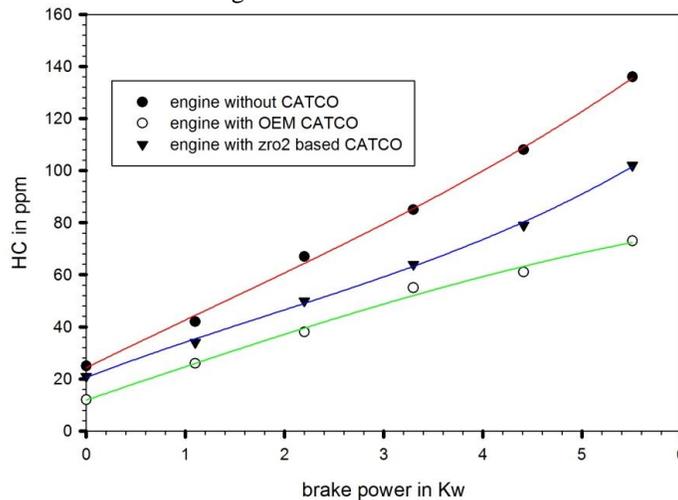


Fig.3 Brake Power VS HC

8.3 Effect of Brake Power on CO₂ Production

From fig.4, it can be seen that as brake power of engine increases CO₂ content also increases due to the fact that more amount of air-fuel mixture is inducted in to the engine at higher load. As more amount of air-fuel is supplied, it produces more amount of CO₂. When catalytic converter is not attached with engine it produces low amount of CO₂. When zirconium dioxide based catalytic converter and OEM catalytic converter is attached with the engine amount of CO₂ increases by 30% and 37% respectively.

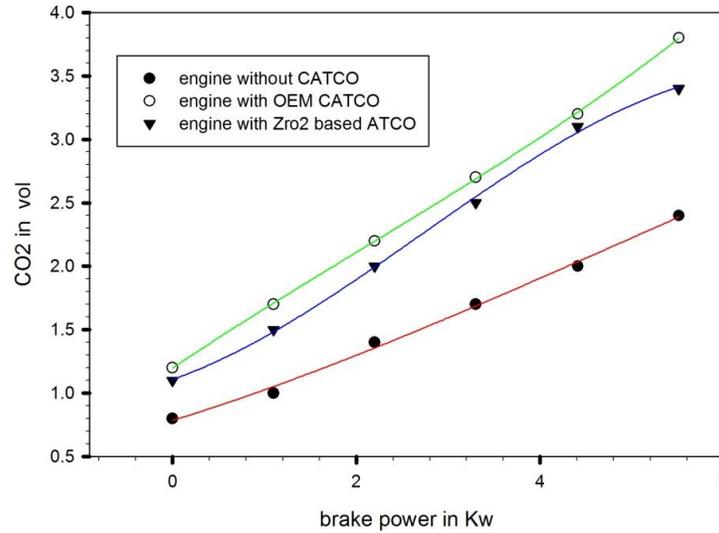


Fig.4 Brake Power VS CO₂

8.4 Effect of Exhaust Temperature on CO Reduction

It can be seen from fig.5, at lower temperature amount of CO is highest as temperature of catalyst increases amount of CO in exhaust reduces. At temperature of 121°C amount of CO in exhaust reduces by 75%. At temperature of 124°C amount of HC in exhaust of diesel is 136ppm. From fig.5, it can be seen that amount of HC in exhaust reduces to 89ppm while diesel was used as fuel. When zirconium based catalytic converter is used, HC reduces by 35% at temperature of 124°C.

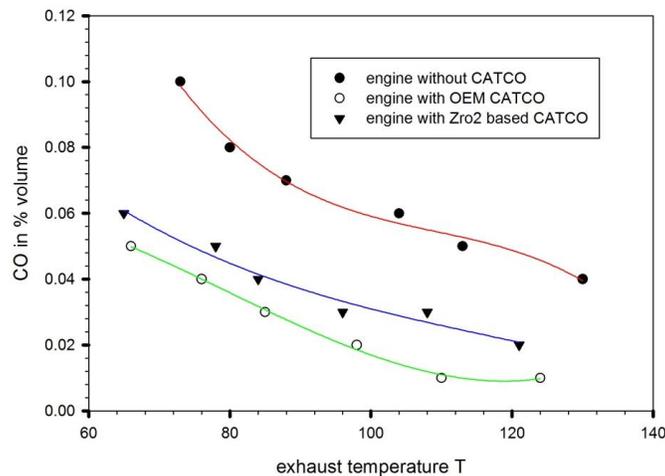


Fig.5 CO Vs Exhaust Gas Temper.

Catalysis process consists of three different processes. (i) Adsorption (ii) reaction and (iii) desorption. A catalytic reaction begins with the adsorption of the reacting gases onto the surface of the catalyst, where intra-molecular bonds are broken or weakened. Next, the adsorbed species react on the surface, often in several consecutive steps. Finally, the products desorbed from the surface into the gas phase, thereby regenerating the active sites on the surface for the catalytic cycle.

8.5 Effect of Exhaust Temperature on CO₂ Production

In the above fig.6, shows that the CO₂ should be increase by increasing the temperature of exhaust in the engine. At the higher temperature 124°C the CO₂ produced in the zirconium based catalytic converter is 30% higher than the diesel engine. At the 130°C the CO₂ produced in the OEM catalytic converter is 37% higher than the diesel engine.

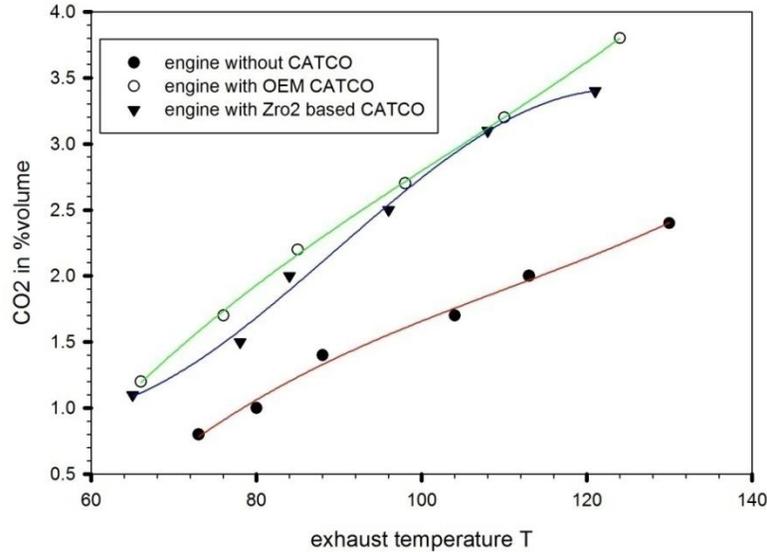


Fig.6 CO₂ Vs Exhaust Gas Temper.

8.6 Effect of Brake power on Back Pressure

Since the after-treatment is applied by providing the zirconium dioxide coated wire mesh placed in the path of exhaust flow, it provides resistance to the flow of exhaust gases, which would affect the engine performance in terms of back pressure on the engine. But it is observed from the fig.7 that back pressure created as a result of zirconium dioxide coated wire mesh placed in between is very small compared to that is created on the engine without any converter mounted on it.

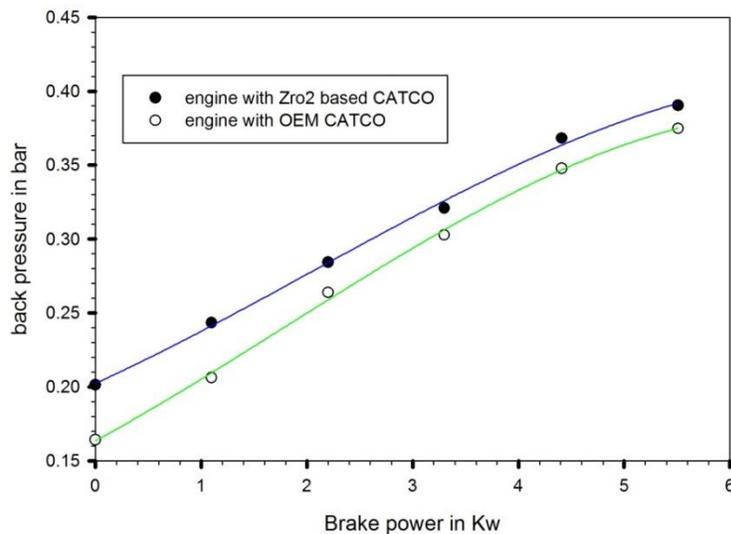


Fig.7 Back Pressure Vs Brake Power

IX. Conclusion

- The reduction of the CO is measured by the zirconium based catalytic converter is reduced 60% than the without catalytic converter. As the exhaust temperature was increased the CO is decreased at the higher 124°C.
- The reduction of the HC is measured by the zirconium based catalytic converter is 35% reduced than the without catalytic converter. As the exhaust temperature was increased the HC is also increased.
- The CO₂ in increased by 30% with the zirconium dioxide based catalytic converter and it increased with the increasing in the temperature.
- The break thermal efficiency of zirconium based catalytic converter with diesel engine is 12% higher than the diesel engine and 8.5% higher than OEM catalytic converter at 10kg load.

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