Scientific Journal Impact Factor (SJIF) : 3.518
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

REVIEW ON IMPROVISING THE PERFORMANCE OF A CI ENGINE BY CHANGING THE MATERIAL OF THE CATALYTIC CONVERTER

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Abstract— In automobile industry, the exhaust from the internal combustion engine is a complex mixture of gases and fine particles. Many pollutants are introduced in the environment such as Carbon Monoxide (CO), Nitrogen Oxides (NOx), Hydrocarbons (HC), etc. These pollutants may lead to affect the respiratory system as well as increase the risk of heart problems, premature death and lung cancer. To control the emission of these pollutants in environment catalytic convertors are used. The commonly used catalyst in convertors is mostly a precious metal such as Palladium, Palladium and Rhodium. Platinum is widely used and very active catalyst, but is very expensive. Rhodium is used as reduction catalyst, while Palladium is used as oxidation catalyst. Since, these materials are expensive the cost of catalytic convertor increases. Thus the purpose of the project is to improve effectiveness of catalytic convertor with optimum cost by studying different catalyst.
Keywords— Catalytic Converter; Zirconium dioxide; substitute material; exhaust emissions

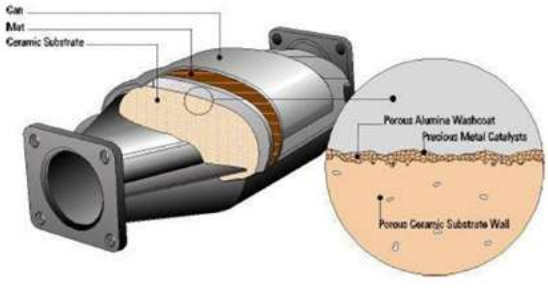
I. INTRODUCTION

During the 20th century, the number of gasoline-driven cars increased from a few thousand to several hundred million on the planet. By the year 2000, approximately 500’000’000 passenger cars were registered world-wide. This caused growth of pollutants in the atmosphere, since almost every vehicle is driven by an internal combustion engine which emits such toxicants such as carbon-monoxide (CO), oxides of nitrogen (NOx) and hydrocarbons (HC) from the exhaust. Therefore, exhaust gas after treatment systems were introduced, which are capable of completing the combustion by means of catalysts, thus reducing the levels of undesired emission components. But this leads to certain problems such as depletion of the catalytic material used in the converter. Thus this results in requirement of change in material. But the currently used materials in catalytic converters i.e. Platinum, Palladium and Rhodium are way more costly. Thus it is required to obtain a substitute material as a catalyst which can give the same or better exhaust emissions and which is cheaper than the noble metals. The main aim of this study is to recognize the materials other than the noble metals which can be used in a catalytic converter and which can give better exhaust emissions.

II. DIFFERENT TYPES OF CATALYTIC CONVERTOR

A. Monolithic Convertor

The monolithic catalytic converter uses ceramic material made in a honeycomb pattern to control the exhaust gases flowing through it. The catalytic elements in the ceramic are enclosed in stainless steel. When ceramic beads are used instead of a honeycomb structure, the unit is known as a pellet catalytic converter.



B. Two way Convertor

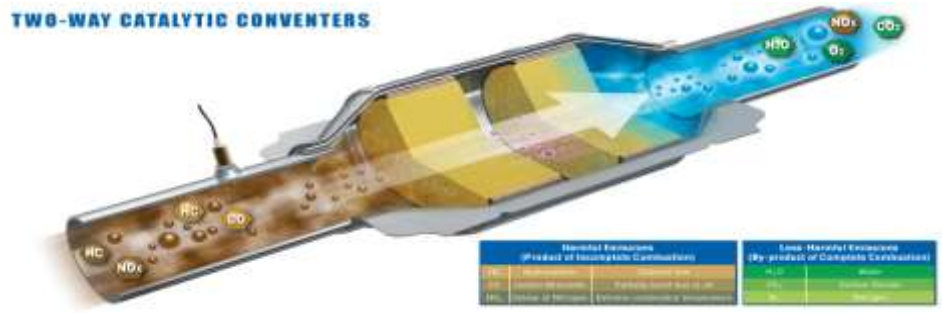
This type is also known as a two-way catalytic converter, because it can only operate with hydrocarbons (unburned fuel) and carbon monoxide (caused by partially-burned fuel). Oxidation converter elements are usually covered in platinum.

Oxidation of carbon monoxide to carbon dioxide:

$$2CO + O2 \rightarrow 2CO2$$

Oxidation of unburnt hydrocarbons (unburnt and partially-burnt fuel) to carbon dioxide and water:

$$CxH2x+2 + 2xO2 \rightarrow xCO2 + 2xH2O$$



C. Three Way Catalytic Convertor

Similar to the oxidation converter, the reduction catalytic converter helps eliminate hydrocarbons and carbon-monoxide emissions, plus oxides of nitrogen emissions, or NOx. NOx emissions are produced in the engine combustion chamber when it reaches extremely high temperatures more than 2,500 degrees Fahrenheit, approximately.

Reduction of nitrogen oxides to nitrogen and oxygen:

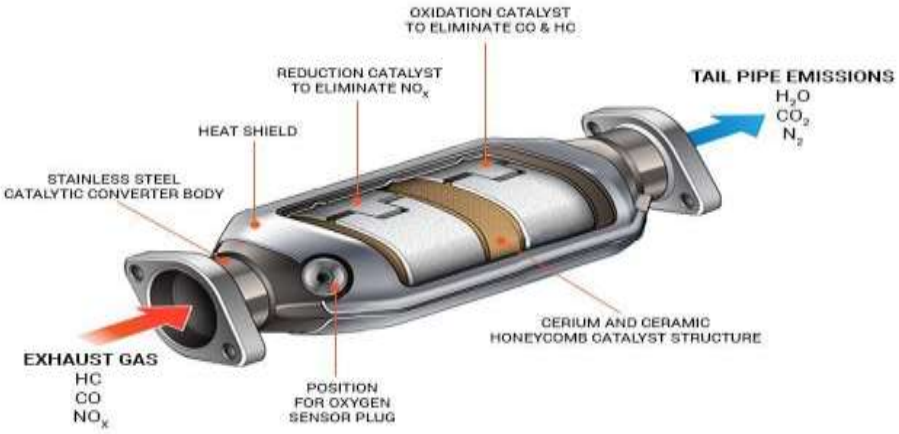
$$2NOx \rightarrow xO2 + N2$$

Oxidation of carbon monoxide to carbon dioxide:

$$2CO + O2 \rightarrow 2CO2$$

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

$$CxH2x+2 + 2xO2 \rightarrow xCO2 + 2xH2O$$



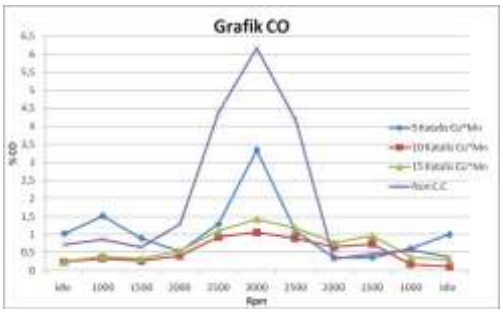
D. Dual Bed Catalytic

This is perhaps one of the most efficient converters. The dual-bed uses a combination of two- and three way catalytic converters housed in a single unit. Both converters are connected through a chamber where incoming emissions are mixed. An air line plugs into the mixing chamber to force air into the chamber to react with the combined emissions and help reduce hydrocarbon and carbon monoxide emissions.

III. LITERATURE REVIEW

1. Optimum Design of Manganese-Coated Copper Catalytic Converter to Reduce Carbon Monoxide Emissions on Gasoline Motor.

This research had been done by RM Bagus, P. Purwanto and H.Hadiyanto to develop a catalyst material useful for reducing the exhaust gas emissions other than the commonly used catalysts such as Platinum, Palladium and Rhodium. The commonly used catalysts were facing the drawbacks such as high cost, scarcity in proportion and they also get depleted due to low levels of lead (Pb) in the exhaust. In this research it was shown that by increasing the number of cells of the manganese coated copper catalyst, the CO emissions reduce to a considerable amount. The figures given below shows the variations in CO emissions by keeping 5, 10, 15 number of cells of Mg*Cu catalyst.



The research was also made by testing on different models of the same catalyst. The average reduction of carbon monoxide in these models is shown in the below table.

Model	5 Cells	10 Cells	15 Cells	Average
1	79,0 %	79,6 %	72,4 %	77,0 %
2	**78,0 %**	**81,5 %**	**79,3 %**	**79,6 %**
3	76,9 %	75,5 %	76,6%	76,2%
4	45,8 %	82,9 %	76,9 %	68,5 %

The conclusion of this research came that use of manganese coated copper as a catalyst in Catalytic converter increases the reduction in CO emissions.

2. Copper based catalytic converter

This research was done by Chirag M Amin, Prof. Pravin P Rathod and Prof. Jigish J Goswami. In this research they used wire meshed copper as a catalyst in the catalytic converter and then conducted experiment for testing the exhaust emissions of Hydrocarbons and carbon monoxide. In this they have also stated different types of failures of the catalytic converters as follows:

a. Converter meltdown
b. Carbon deposit
c. Catalyst fracture
d. Poisoning

The research was conducted to check the variations in the emissions with the variations in the temperatures and the brake power. It was observed that with increase in temperature the CO and HC conversion capacity increases and with increase in brake power the capacity of CO and HC Conversion decreases

The wire mesh coated with copper is shown in figure.

From this research it was concluded that the use of copper based catalytic converter reduces emissions of HC by 38% and CO by 33%.

3. Emission Characteristics of a Compression Ignition Engine Using Different Catalyst.

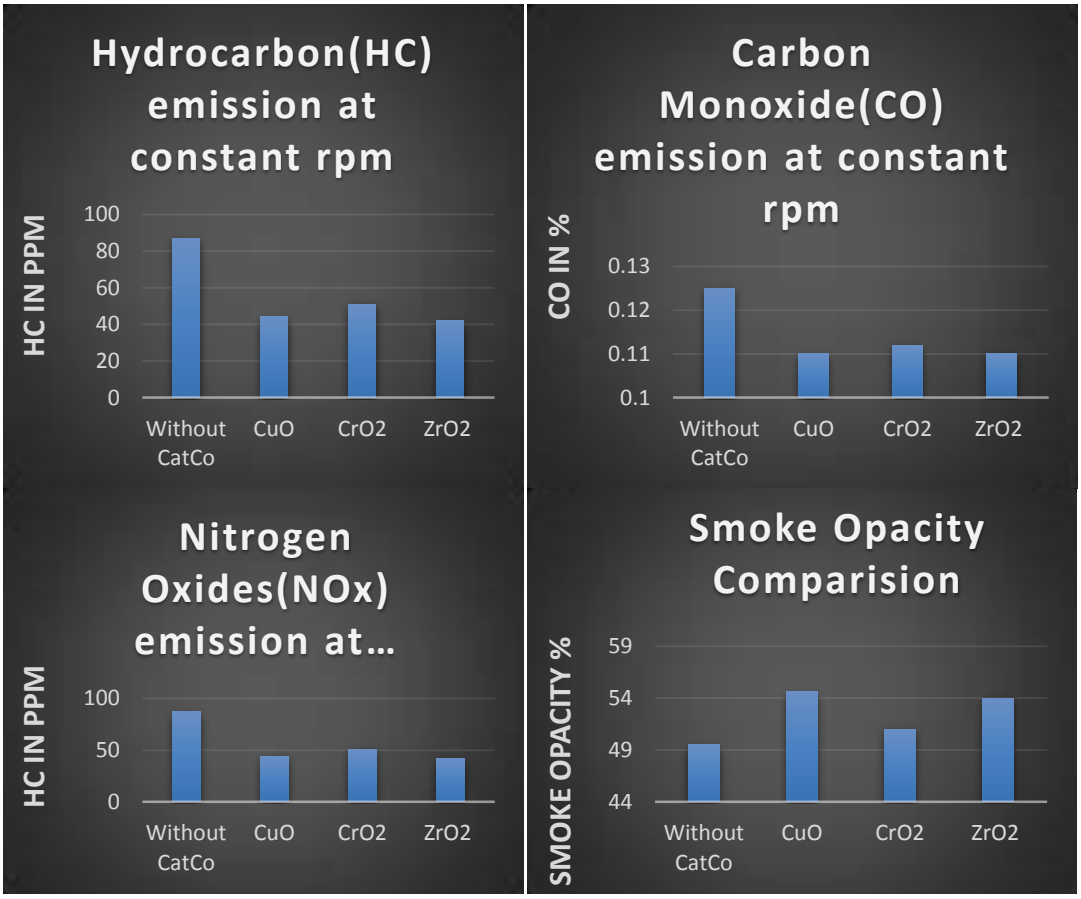
P. V. Walke, Dr. N. V. Deshpande, A.K.Mahalle had done a research on Catalytic converter with different catalyst for compression ignition engine to reduce pollute gases. In this they have also shown the fabrication of a catalytic converter and also the design calculations for different parts of the catalytic converter such as volume of catalytic converter, shell dimensions, volume of inlet cone and design of spacer.the specifications for the engine used for the experiment are as follows:

Engine specification

- Compression ratio – 17.5 : 1
- Bore – 102 mm
- Stroke – 116 mm
- Power – 10 BHP (7.4 KW)
- Arm Length – 180 mm
- Maximum torque – 32 N-m
- RPM – 1500

The catalysts used by them were:

- Copper oxide (CuO) pellets
- Cerium oxide (CrO2) pellets.
- Zirconium dioxide (ZrO2) pellets.



By conducting the experiment the following conclusion was developed:

A zirconium dioxide catalyst reduces HC Emission.

2. All three catalysts (zirconium dioxide, cerium Oxide and copper oxide) reduce CO emissions.
3. The catalyst (zirconium dioxide + cerium oxide), reduce NOx emission
4. Brake thermal efficiency decreases nominally with Catalytic converter.

4. Design and manufacturing of Nanocatalytic converter for pollution control in automobiles for green environment

The study was performed by Durairajan A, Kavitha T, Rajendran A and Kumaraswamidhas LA. The study showed the behaviour of catalytic convertor and the effect of catalytic convertor on reduction of toxic emmisions like CO, Nox and HC using nano rhodium and nano palladium as catalysts. The result was carried out for exhaust without catalytic convertor, catalytic convertor without coating and catalytic convertor with coating.

The study provided data about reduction in Co, NOx and HC at no load condition and peak load condition. The results show that at no load condition the reduction were 33.33% in Nox, 72% in HC and 60% CO. The performance at maximum torque and maximum power i.e. Peak load show the reduction were 84.3% in NOx, 78% in HC and 69% in CO.

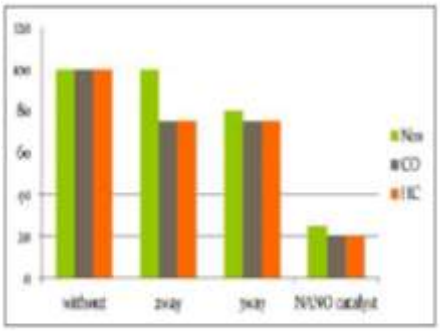


Fig. 11. Comparison of NOx, Co and HC values

5. Development of Low Temperature Active Catalysts for CO and VOC Abatement

Monika Molin examines different catalyst for oxidation of carbon monoxide, dimethyl ether and methanol in Emission Control System. To obtain low light off temperature the catalysts used were palladium and platinum with metal oxides of cerium, cobalt, iron, manganese, copper, tungsten and magnesium. The experiment with different mol % of palladium and platinum as catalyst with addition of different metal oxides to reduce light off temperature.

The observations show that molar ratio of 80 mol percentage palladium and 20 mol percent platinum using cerium oxide as a promoter for low light off temperature and high conversion. Manganese oxide use lower light off temperature only for platinum but not for palladium. Addition of Cerium Oxide lowered light off temperature for both platinum and palladium.

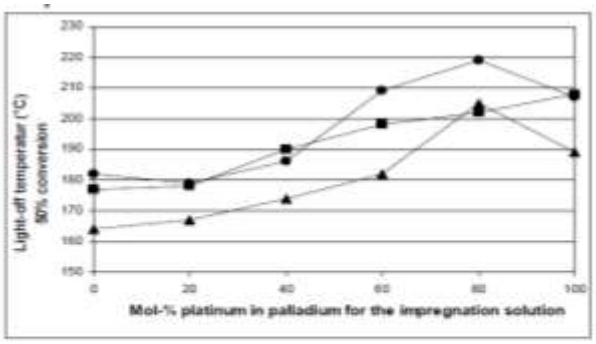


Figure 1. The effects of the mol % of platinum and the calcination method for combined palladium and platinum catalysts. Catalysts calcined in the temperature programmed oven (■), catalysts calcined in the catalyst factory (▲), and according to a reference article (●) [7].

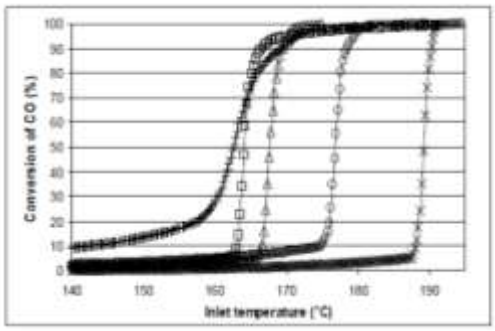


Figure 2. The light-off behaviour for different catalysts. Pure palladium (■), pure platinum (×), palladium promoted with CeO_x (+), platinum promoted with CeO_x (●) and a combined palladium and platinum catalyst with a molar ratio of 80:20 Pd/Pt (▲).

6. Exhaust analysis of C.I engine by using zirconium dioxide coated Wire mesh catalytic converter

The study was performed by Krunal P. Shah and Dr. Pravin P. Rathod. The study showed the use of different metal oxides as catalysts in catalytic convertor. The metal oxides used are Copper Oxide, Cerium Oxide and Zirconium Dioxide. Comparison was performed keeping the rpm constant.

The results show that the most effective catalyst is Cerium Oxide of the metal oxides catalyst used. The zirconium dioxide is least effective catalyst. The smoke opacity of combined zirconium dioxide and cerium oxide is high compared to other catalysts. The wire mesh structure increases the surface contact area thus increasing the efficiency.

IV. CONCLUSION

After studying all literature review it can be seen that the noble metals Platinum, Palladium and Rhodium, used widely are active catalysts but are expensive. The solution to this is use of materials such as manganese coated copper, zirconium dioxide, cerium oxide and copper oxide in place of the conventional noble metals as catalysts. The results of the exhaust emissions obtained were quite satisfying. There was a notable effect of temperature, brake power etc on the working. The use of these materials gave quite satisfying results of the engine emissions. Also the fact can be ignored that these materials are way too cheaper than the noble metals. Thus, the reduction in environment pollution can be achieved at optimum cost by using effective catalytic convertor.

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