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Catalytic Converter Used in Automobiles -A Review

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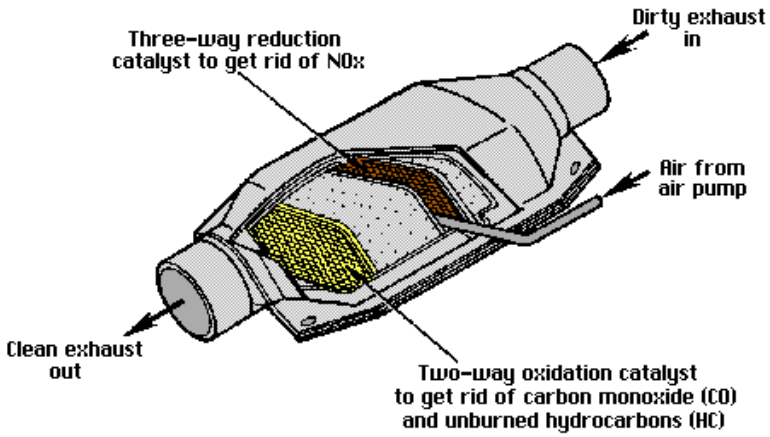
Abstract *—Exhaust emissions of much concern are Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NOx) from the automotive vehicles. Catalytic converter oxidizes harmful CO and HC emission to CO2 and H2O in the exhaust system and thus the emission is controlled. Reduction of toxic substances emission from combustion engines can be achieved in automotive exhaust after treatment process is applied based on oxidation and reduction processes which are takes place in catalytic converter. This paper deals with various types of materials of low cost which can be used in a catalytic convertor as well as detailed study of the exhaust emissions coming out of the catalytic convertor as well as its performance analysis.*

Keywords*-Exhaust emission, Catalytic converte ,Copper catalyst, Nickel catalyst, Diesel engine*

I. INTRODUCTION

A catalytic converter is a vehicle emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction (oxidation or reduction). Catalytic converters are used in internal combustion engines fueled by either petrol (gasoline) or diesel—including lean burn engines. "Two-way" converters combined carbon monoxide (CO) with unburned hydrocarbons (HC) to produce carbon dioxide (CO2) and water (H2O). In 1981, two-way catalytic converters were rendered obsolete by "three-way" converters that also reduce oxides of nitrogen (NOx) however, two-way converters are still used for lean burn engines. Although catalytic converters are most commonly applied to exhaust systems in automobiles, they are also used on electrical generators, forklifts, mining equipment, trucks, buses, locomotives, motorcycles, and airplanes. They are also used on some wood stoves to control emissions.

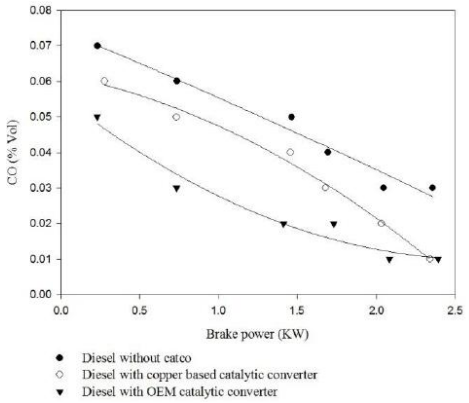


"***Figure 1. Catalytic Converter"***

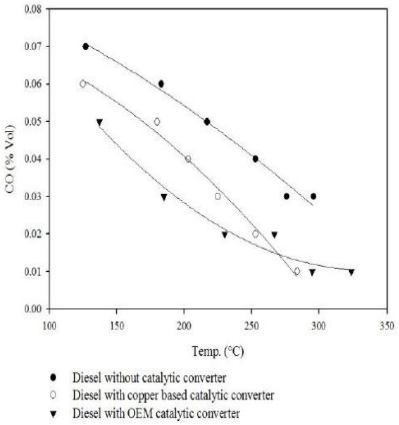
II. LITERATURE REVIEW

2.1. Chirag M. Amin, Prof. Pravin P. Rathod, Prof. Jigish M. Goswami, "Copper based catalytic Converter" [1]

Exhaust emissions of much concern are Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NOx) from the automotive vehicles. Catalytic converter oxidizes harmful CO and HC emission to CO2 and H2O in the exhaust system and thus the emission is controlled. There are several types of problems associated with noble metal based catalytic converter. These factors encourage for the possible application of non-noble metal based material such as copper as a catalyst, which may by proper improvements be able to show the desired activity and can also offer better durability characteristics due to its poison resistant nature. The present work is aimed at using copper as a catalyst for catalytic converter. Wire mesh copper catalytic converter is developed for a volume of 1.54 m3. The experiment is carried out on four stroke single cylinder CI engine. The optimum values of exhaust emissions found at full load are HC (130 ppm), CO (0.07 %). By using copper based catalytic converter it is found that HC is reduced by 38 % and CO by 33 % at full load. Fig. 1 and Fig. 2 shows the performance of emission of CO,HC with respect to Brake power under different circumstances. Fig. 3 shows the variation in CO(%vol) with respect to Temp.



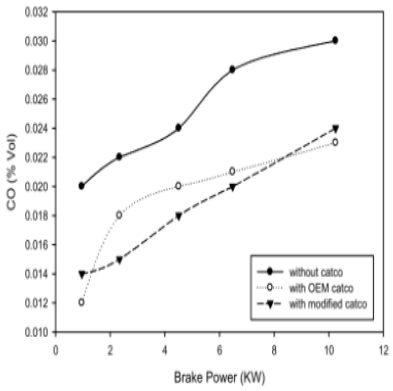
"*Figure 2. CO vs BP"*



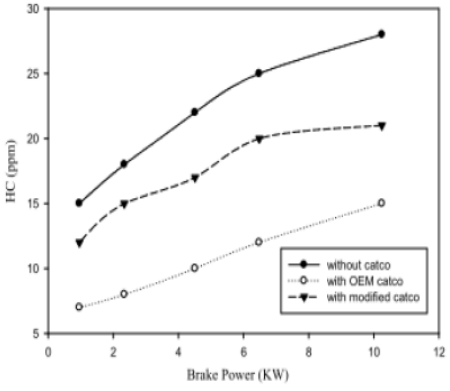
"*Figure 3. CO vsTemp"*

2.2. Narendrasinh R. Makwana, Prof. Chirag M. Amin, Prof. Shyam K. Dabhi, "Development and performance analysis of nickel based catalytic convertor" [2]

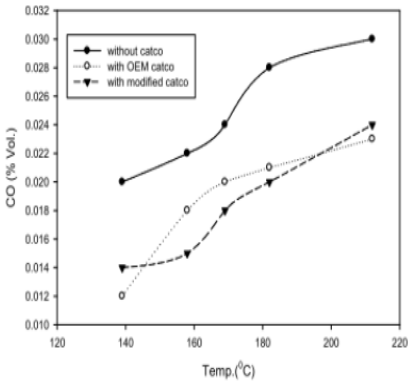
In this paper, the author has carried out the experiment using a nickel based catalytic convertor and the performance has been analysed. From experimental data following analysis can carried out when diesel was used as fuel seen from fig. 4, that during starting of diesel engine carbon monoxide contents are highest in the exhaust because during starting of engine rich air supplied to the engine sand also due to incomplete combustion of fuel. Again as load on engine increases fuel consumption also increase which can be seen in fig. 4. From fig. 5, it can be seen that as brake power of engine increases, hydrocarbon content because of increase in fuel consumption. Generally, hydrocarbon is produced due to incomplete combustion. From above diagrams it can be seen that as temperature of catalyst increases, its ability to convert CO and HC into H2O and CO simply we can say that its conversion efficiency increases. It can be seen from fig. 6 and fig. 7 at lower temperature amount of CO is highest as temperature of catalyst increases amount of CO in exhaust reduces.



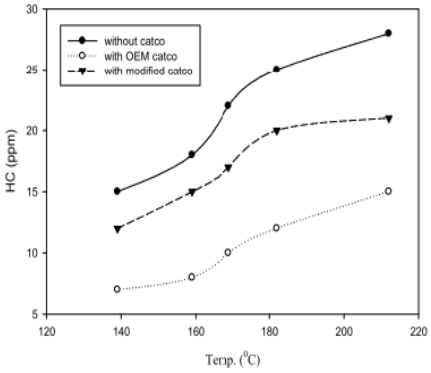
"Figure 4. CO vs BP"



" Figure 5. HC vs BP"



"*Figure 6. CO vs Temp.*"



"Figure7. HC vs Temp"

2.3. Francisco Payri, Jesus Benajes, and Jose Galindo, "One-dimensional Fluid –Dynamic Model for catalytic converter in automotive engines" [3]

In this paper, the author has studied one-dimensional fluid –dynamic Model for catalytic converter in automotive engines. The main aim of this paper was to present a simple approach to the one dimensional modelling of the fluid dynamic behaviour of the catalytic converter. They developed a geometric model that was capable of completely representing the dynamic behaviour of the converter, that is, its reflection and transmission characteristics.

2.4. Cathy Chung, Sivanandi Rajadurai and Larry Gee, "CFD Investigation of Thermal fluid flow and Conversion characteristics of the catalytic converter" [4]

In this paper, the author has studied the CFD investigation of thermal fluid flow and conversion characteristics of the catalytic converter. Their main objective was to predict the maximum operating temperature for appropriate materials and to develop a numerical model, which can be adjusted to reflect changes in the catalyst/washcoat formulation to accurately predict effects of flow, temperature and light off behaviour. They concluded that by changing the concentrations, the converter characteristics and steady state temperature could be changed.

2.5. Prof. Bharat S Patel, Mr Kuldeep D Patel, "A Review paper on Catalytic Converter for Automotive Exhaust Emission" [5]

In this paper, the author has performed detailed analysis of the exhaust emission coming out of the catalytic convertor. The paper concludes that today's automobiles are meeting emission standards that require reductions of up to 99 percent for HC, CO and NOx compared to the uncontrolled levels of automobiles sold in the 1960s. Among all the types of technologies developed so far, use of Metal Monolith type catalytic converters is the best way to control auto exhaust emission. Three-way catalyst with stoichiometric engine control systems remain the state of art method for simultaneously controlling hydrocarbon, CO and NOx emissions from vehicle.

2.6. Julia Windmann, Joachim Braun and Peter Zacke, "Impact of the inlet flow distribution on the light off behaviour of a 3-way catalytic converter" [6]

In this paper, the author has studied the impact of the inlet flow distribution on the light off behaviour of a 3-way catalytic converter. This paper presents a three-dimensional transient numerical study of the influence of the velocity distribution in front of the inlet face of the monolith during light off of a three-way catalytic converter. The difference in the thermal and chemical behavior due to the shape of the velocity distribution is discussed in this paper.

III. CONCLUSION

- Though not a noble metal, copper works as a catalyst for the conversion of pollutants in exhaust but in a limited proportion. Experimental results shows that, by using copper based catalytic converter, HC reduces by 38% and

CO reduces by 33%. It is therefore concluded that development of copper based catalytic converter is feasible since it gave satisfactory results for given operating conditions and reduction of HC and CO emissions.

- A simple low cost; non noble (nickel) based catalytic converter to reduce diesel engine exhaust emission. Though not a noble metal, nickel works as a catalyst for the conversion of pollutants in exhaust but in a limited proportion. By using nickel based catalytic converter, HC reduces by 40% and CO reduces by 35%.
- As the mass flow rate increases the pressure drop also increases. The conversion efficiency depends upon the substrate temperature and composition of the inlet. By increasing the temperature the conversion efficiency also increases.
- At lower temperature the catalytic converter will be inactive. The heat release due to chemical reaction does not play a significant role.
- Catalytic converters are also used to reduce emissions from alternative fuel vehicles powered by natural gas, methanol, ethanol and propane.

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