Fabrication and Experimental Investigation on Emission of Internal Combustion Engine

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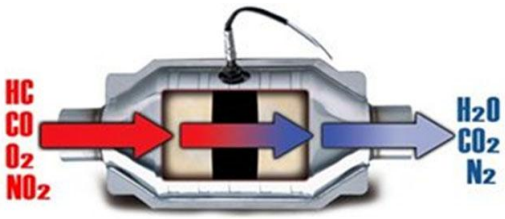
Abstract*: This paper represents the effect of various wash coat materials on a new catalytic converter used for diesel engines to reduce toxic gases. These toxic gases contain NOx, CO, HC and smoke, which are harmful to the environment as well as humans. The number of alternative technologies such as improving engine design, fuel pre-treatment, alternative fuel use, fuel additives, exhaust treatment or better tuning of combustion process etc. are considered to reduce the engine's emission level. We are fabricating and investing the experimental data of the three way catalytic converter, which are based on the different oxidation and reduction catalyst used in the converter. Wash coat materials are Zirconium Dioxide (ZiO_2) with molybdenum trioxide (MoO_3), titanium dioxide (TiO_2), aluminum oxide ($Al2O_3$), copper nitrate ($CU(NO_3)_2$), molybdenum trioxide (MoO_3), and monolith substrate. The objective of this paper is to develop the three way catalytic converter, which is more-effective and less cost using different wash coat material. Detailed review on the results of this new catalytic converter and emission test has been presented with discussion.

***Index Terms*: Catalytic converter, Ceramic block, Magnetic Stirrer, Al_2O_3, Cu $(NO_3)_2$, TiO2, ZiO_2**

I. INTRODUCTION

The basic knowledge about the catalytic converter is essential to design a new catalytic converter. A catalytic converter is an exhaust emission control tool that regulates CO and HC with oxidation and deficiency by NOx. This converter operates in two stages. The first stage of the converter uses platinum and rhodium to reduce the NOx in the exhaust into nitrogen and oxygen. The converter acts as an oxidizing catalyst to convert HC and CO into water and CO_2 in the second phase of platinum and palladium.

I.I How catalytic converter works?



"Fig." 1 Catalytic converter

The first step of the catalyst in the catalytic converter. It uses platinum and rhodium to reduce NOx emissions. As soon as the gas enters inside, the nitrogen molecules first react. The catalyst causes nitrogen oxides to convert nitrogen and oxygen respectively.

$$Oxides\ of\ Nitrogen\ (NO_x) \rightarrow Oxygen(O_2) + Nitrogen(N_2)$$

The gas then flows through the micro ducts of the second ceramic block where it reacts with the platinum and palladium.
Here the Carbon monoxide reacts with oxygen molecules to form Carbon Dioxide (CO_2).

$$Carbon\ Monoxide\ (CO) + Oxygen\ (O) \rightarrow Carbon\ Dioxide(CO_2)$$

Unburned hydrocarbons also react with oxygen to make water and carbon.

$$Hydrocarbos(HC) + Oxygen(O_2) \rightarrow Water(H_2O) + Carbon\ Dioxide(CO_2)$$

II. RESEARCH METHODOLOGY

In an existing catalytic converter, precious metals such as platinum, palladium and rhodium are commonly used. To overcome the cost and use of precious metals, it was an attempt to identify the results of the project experiments using alternative sources of material.
Monolith ceramic is taken into the oxidation catalyst and reduction catalyst solution in the wash coat technique. Wash coat helps in the oxidation process to reduce the CO, HC emission and reduction process to reduce NOx emissions. New tests will prove the concept of alternative materials compared to precious metals employed in recent trends, and will increase the viability of cost-effective solution.

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❖ **Reduction Catalyst:**
Wash Coat: Titanium dioxide (TiO_2), Aluminum oxide (Al_2O_3), Molybdenum trioxide (MoO_3)

❖ **Oxidation Catalyst:**
Wash Coat: Copper nitrate ($Cu(No_3)_2$), Zirconium Dioxide (ZIO_2), Molybdenum trioxide (MoO_3)

At last, we will fabricate and assemble both ceramic in a single chamber. Material required for fabrication of new catalyst based catalytic converter is as follows:-

a) Monolith ceramic block
b) Distilled water and Concentrated HCL
c) Chemical catalyst.
d) Glass wool (for insulation purpose)

EXPERIMENTAL WORK DONE

Experimental Steps for Coating process

Step: 1 Monolith ceramic block is dipped into HCL solution so that to remove impurities meanwhile to obtain clean surface so that good coating takes place.

"Fig." 2 Monolith ceramic block is dipped into HCL Solution

Step 2: After washing the ceramic block into HCL, further it is washed with distilled water to clean out HCL from surface and to get chemical free clean surface.

Step 3: Let the ceramic block to be dry by keeping it into Hot air oven at temperature of 70ºC to 80ºC.

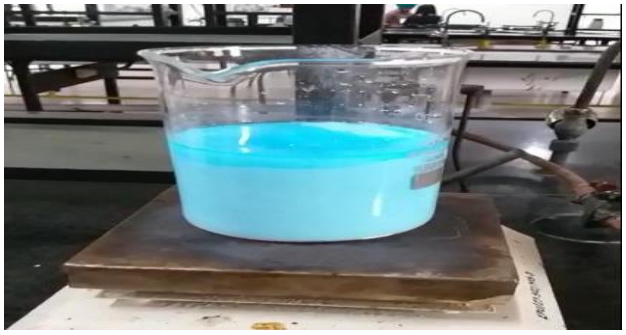
"Fig." 3 Hot Air Oven

Step 4: Preparing the chemical solution which has to be coat over two different monolith ceramic block (Reduction and Oxidation catalyst):

- **Reduction Catalyst:** Preparing the wash coat solution for coating by stirring process for 6hrs. Which is carried out in magnetic stirrer apparatus, the stirrer magnet is placed inside the beaker containing solution of following mixture: Titanium dioxide (TiO2), Aluminium oxide (Al_2O_3) Molybdenum Trioxide (MoO_3) Temperature maintains through the process is 60ºC to 70ºC.

"Fig." 4 Solution of Reduction Catalyst

- **Oxidation Catalyst:** Preparing the wash coat solution for coating by stirring process for 6hrs. Which is carried out in magnetic stirrer apparatus, the stirrer magnet is placed inside the beaker containing solution of following mixture: Zirconium dioxide (ZiO_2), Copper Nitrate ($Cu(NO_3)_2$, Molybdenum Trioxide (MoO_3). Temperature maintain through the process is 60ºC to 70ºC.



"Fig." 5 Solution of Oxidation Catalyst

Step 5: Dip the ceramic block into prepared wash coat solution for 30 min immediate after stirring process is complete to perform coating process and repeat the process 2-3 times. And then let it dry for more than 24 hours at room temperature so that it will dry completely and form good coating layer over the ceramic block.

"Fig." 6 Reduction catalyst ceramic block after coating

"Fig." 7 Oxidation catalyst ceramic block after coating

III. ASSEMBLING OF CATALYTIC CONVERTER

Catalytic Converter is assembled by placing ceramic block surrounded by wool for providing insulation. Thus coated ceramic block placed inside the chamber to react with emission coming out from the engine. Now the welding process completed the new catalytic converter. After the fabrication of catalytic converter are ready for the testing of emission.

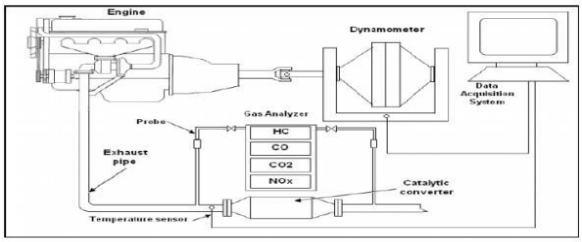
"Fig." 8 Both ceramic block placed in a casing

""""Fig." 9 Fabricated Catalytic converter having inlet and outlet manifold

IV. PROCEDURE FOR EMISSION TESTING

When the engine is in the current state it exceeds too much pollution (HC, CO, CO2, NOX) because we mount the catalytic converter on the exit pipe of the engine and before the catalytic converter increases, two different Investigations are attached i.e. in the inlet side of the converter and on an outlet so that measure and compare emission

"Fig." 10 Experimental setup for emission testing



characteristics. When the exhaust gases fly in the catalytic converter, the catalyst reacts with the catalyst and changes into the desired output and the effect of the catalyst on the harmful exhaust gases is shown on the data acquisition system of the emission testing machine, an exhibit is automatically comparable the graph shows the reading.

V. RESULT AND DISCUSSSION

"Table." 1 Experimental reading

Analysis term	Engine without catalytic converter and without load	Engine with catalytic converter and without load	Engine with catalytic converter and with load
CO Carbon monoxide	0.036%	0.056%	0.045%
HC Hydro carbon	52 ppm	44 ppm	39 ppm
CO_2 Carbon dioxide	2.70%	1.60%	1.20%
O_2 Oxygen	16.48%	18.11%	18.66%

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NO_x Nitrogen oxide	1811 ppm	256 ppm	214 ppm
Oil Consumed	51.2 C	51.1 C	51.2 C

In order to reduce the polluted gas, the catalyst converter with the different catalysts for the engine is selected for the current work. Emphasis on oxide of hydrocarbons (HC), carbon monoxide (CO) and nitrogen. Monolith ceramic blocks are coated with molybdenum trioxide (MoO_3), titanium dioxide (TiO_2), aluminum oxide (Al_2O_3), copper nitrate ($Cu(NO_3)_2$), molybdenum trioxide (MoO_3) and zirconium dioxide (ZiO_2). Both cut based catalysts and oxidation based catalysts and monolith substrates are put together at two ends of the converter shell in a quadrilateral housing. A spacer was used between quadrilateral housing with monolithic blocks to separate the distance and reduce the pressure back on the engine. Zirconium dioxide catalysts reduce the HC emission. Reduction catalyst copper nitrate ($Cu (NO_3)_2$), molybdenum trioxide (MoO_3) and Zirconium dioxide (ZiO_2) reduce CO emissions. Catalyst molybdenum trioxide (MoO_3), titanium dioxide (TiO_2), aluminum oxide (Al_2O_3), reduces NOx emissions. Brake thermal efficiency with the catalytic converter decreases.

Experimental results show that, using different catalysts, HC decreases by 27% and CO_2 decreases by 55% and CO and NO_X also decreases by unprecedented difference. Therefore, it has been concluded that development of deficiency and oxidation based converter is possible with different wash coat material because it has given satisfactory results for operating conditions and reduction in HC and CO emissions. And it also reduces the overall cost of the converter compared to the convention converter used in the automobile.

VI. CONCLUSION

The summary of the current review is as follows:

Devices developed after the exhaust emission treatment developed exhaust analysis of the engine using thermal converters or reactors, for Exhaust analysis of engine by using Molybdenum trioxide (MoO_3), Titanium dioxide (TiO_2), Aluminium oxide (Al_2O_3), Copper nitrate ($Cu(NO_3)_2$), Molybdenum trioxide(MoO_3), and Zirconium dioxide (ZiO_2) with monolith substrate is an effective ways to reduce harmful emission from the automobile exhaust, and also it is economical as compared the conventional catalytic as these catalyst/ Wash coat materials are very less costly in the comparison of noble metal like platinum, palladium and rhodium. The converter, CO_2 and H_2O oxidizes the harmful CO and HC emission in the emission system and thus emits control.

Experimental conclusion is as follow:

a) HC (Hydro Carbon) is reduced by 27%
b) CO2 (Carbon Dioxide) is reduced 55%
c) O2 (Oxygen) is increase by 13.2%
d) HC and CO is also reduced by phenomenal difference.

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