Performance Study of Gold Plated Catalytic Converter Treatment System for Diesel Engine Emission

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Abstract – In the last years, the world has been confronted with an energy crisis. The most use fuel and petroleum are becoming scarce and its use is associated with the increase of environmental problems. The concerns about clean environment driving forces for the research on catalytic converter which use for reduce the harmful exhaust emission from C.I. engine which are the NOx, CO, HC and CO2.

Gold Nano particles are used in automotive catalytic converter for selective oxidations of CO and hydrocarbon. Gold has been considered as an active catalyst only when suitable techniques of preparation provided high metal dispersion.

In this project the control strategies and achievements in automotive pollution control are studied. Attention is focused on the replacement of catalytic platinum with gold catalytic and the performance of modified exhaust after treatment system.

The results obtained for with DPF+ Gold based TWC converter +DEF system connected at the end of exhaust tail pipe were compared with DPF+TWC based converter connected at the end of exhaust tail pipe and without connecting catalytic converter at the end of exhaust tail pipe in terms of concentration of CO, HC, NOx and CO_2. Significant improvement is observed at nominal cost.

Keywords- Gold Plated Catalytic Converter, Exhaust Treatment System, Diesel Engine Emission, Gold Nano Particle.

I. INTRODUCTION

We have several ways for controlling automobile pollution but most effective way is by using catalytic converter in the automobile. Bharat stage emission standards are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engine equipment, including motor vehicles. Under such conditions TWCs effectively remove the pollutants.

As for the exhausts originated by diesel, let us observe that even though diesel engines run in an excess of oxygen, typically 8.85 of O2 is present in the exhausts compared to approximately 1% found in the engine fed at stoichiometric; However, as far as the HCs are concerned, there is an important difference in that very low levels are emitted from the diesel engine (NOx), which makes necessary addition of a reducing agent to the exhaust in order to achieve appreciable reduction of the emitted NOx.

This emission problem can be controlled by using catalytic converter. Under Steeple's guidance GM built on existing research to produce the first catalytic converter for use in an automobile.

Catalytic converters were first installed in vehicles made in 1975 in response to EPA regulations passed two years earlier tightening auto emissions and requiring a gradual decrease in the lead content of all gasoline.

In a study released on nov.28, 1973, the EPA determined "that lead from automobile exhaust was posing a direct threat to public health." Although catalytic converter was developed in the 1950s, the device couldn't be used in vehicles because the lead in gasoline would render them useless.

Since the introduction of stringent emission regulation in the US in the 1970s, car manufactures have modified their exhaust systems to incorporate catalytic converters for the removals of NOx, CO and hydro carbons. The four menu options on the left allow users to:

- Gain an overview of the importance, sources and trends in emissions of air quality pollutants and GHGs
- Investigate in more detail the sources, environmental and human health effects and trends in emissions of the wide range of pollutants recorded in the NAEI.
- Understand the methods used to generate projections of air quality pollutants and GHGs, and access data sets of projections.

II. LITERATURE REVIEW

In15 March 1993, Akira Obuchi, Akihik Ohi, Masato Nakamura, Atsushi Ogata, Koichi Mizuno and Hideo Ohuchi [1] studied the performances of platinum-group metals, platinum, iridium, palladium, rhodium and ruthenium supported on γ-alumina, as catalysts for the selective reduction of nitrogen oxides by hydrocarbons were investigated and confirmed that the platinum-rhodium and platinum catalysts have higher. The platinum-containing catalysts, however, produced more nitrous oxide than nitrogen. It is expected that platinum-group metal catalysts will be able to be used for practical purposes if once their selectivity toward nitrogen is improved.

Andrea Scotti, Isabella Nova, Enrico Tronconi, Lindia Castoldi, Luca Lietti and Pio Forzatti [2] studied NOxstorage on the catalyst during lean and rich fuel condition and they found that lean NOx Trap (LNT) catalysts are capable of reducing. NOx in lean exhaust from diesel engines. NOx is stored on the catalyst during lean operation; then, under rich exhaust conditions, the NOx is released from and reduced by the catalyst. The process of NOx release and reduction is called regeneration. One method of obtaining the rich conditions for regeneration is to inject additional fuel into the engine cylinders while throttling the engine intake air flow to effectively run the engine at rich air: fuel ratios; this method is called "in- cylinder "regeneration. In-cylinder regeneration of LNT catalysts has been demonstrated and is a candidate emission control technique for commercialization of light-duty diesel vehicles to meet future emission regulations.

Brian West, Shean Huff, James Parks, Sam Lewis, Jae-Soon Choi, William Partridge and John Storey [3] studied Characterization of the exhaust reductant chemistry during in-cylinder regeneration and effects of various injection strategies resulting exhaust chemistry on the performance of the LNT. The effect of various injection parameters on exhaust chemistry species and LNT performance are discussed. They found that the fuel chemistry does affect engine-out hydrocarbon (HC) species, but not engine-out carbon monoxide (CO) or hydrogen (H2) generation. Higher engine-out CO and H2 correlate to improved NOx reduction, irrespective of HCs.

Felix Birkhold a, Ulrich Meingast a et al [4] discuss about Modeling and simulation of the injection of urea-water-solution for automotive SCR De NOx-systems. C. Scott Sluder et al, from Oak Ridge National Laboratory discusses about Low Temperature Urea Decomposition and SCR Performance. Rinie van Helden et al, discussed Optimization of Urea SCR DeNOx Systems for HD Diesel Engines.

Hans-Dieter Harder, Marc Brugger et al [5] discuss Future SCR NOXAfter treatment Systems for Euro 6. It is also identified about Volume saving factor relative to liquid urea tank with same ammonia quantity & Ad Ammine Safe solid-state ammonia storage.

Jenny-Yue Zheng [6] discusses NOxself-inhibition in selective catalytic reduction with urea (ammonia) over a Cu-zeolite catalyst in diesel exhaust.

Ricardo Department of Chemistry and Applied Biosciences, ETH Zurich, [7] has been commissioned by Coordinating Research Council to perform a comprehensive search of several scientific databases in order to assess the state-of-the-art of selective catalytic reduction of NOx using hydrocarbons as the reductant source. The objective is to identify potential catalyst formulations which show promise as emission control technologies to be used in LDD applications. To this end, Ricardo Power link, Compendex, INSPEC, NTIS, CAB Abstracts and CHEMWEB – Catalysis Forum have been searched using the following keywords: Selective Catalytic Reduction, SCR, NOx Reduction, Diesel Exhaust, Lean, DeNOx, Non urea/ammonia. From this search, 289 papers have been identified from which 122 have been selected for detailed reading. A catalyst formulation is defined as a potential ECT if the peak NOx conversion occurs below 300°C and the conversion levels are greater than 70%.

The conceptual model of Urea Dosing System Denoxtronic 3.1 developed by Bosch has been in series production at several OEMs since mid-2008. Application of the Denoxtronic 3.1 already enables compliance with Euro 6 and Tier2 Bin5 limits & is the base for most of the recent work in the area. Possible applications: The Denoxtronic 3.1 is primarily designed for use in passenger cars and in the light-duty segment. Further possible applications exist in the off-highway segment for engines in the range 56-100 kW. (SCR Technology for NOx Reduction: Series Experience and State of Development Manuel Hesser, Hartmut Lüders, Ruben-Sebastian Henning Robert Bosch Corporation / Robert Bosch GmbH) [8].

In this project we studied detailed about catalytic converter (platinum, rhodium and palladium) as various catalysts used in catalytic converter, their properties and how they are controlling emissions coming from vehicles and how gold can be more effective by using gold instead of platinum and we have replaced platinum with gold and we have conducted test by multi gas analyzer and compared effectiveness of gold with platinum.

III.BASIC COMPONENTS

3.1 CATALYTIC CONVERTER:

A catalytic converter is an 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 with internal combustion engines fueled by either petrol (gasoline) or diesel. The normal catalytic converter is shown in Fig 3.1

Fig 3.1: Three way Catalytic converter

Table 1: Specification of Three way catalytic converter

Catalyst/Silencer Model Number	IQS-20-08-EC2
Material*	304 SS
Diameter	5.4 cm
Outlet Pipe Size & Connection	1FeetFFFlange
Inlet Pipe Size & Connection	2 feet FFFlange
Instrumentation Ports	2 inlet/2 outlet
Cells Per Squarecm	70
Converter Pressure Loss	3.0 in WC

3.2 DIESEL PARTICULATE FILTER (DPF):

The catalyst commonly contains an alumina wash coat supported on a honeycomb shape ceramic brick and in (DPF) oxidizing catalyst breaks down into SOF and then it enters into filter which traps and burn soot and the amount of PM reduced as shown in Fig.

Fig 3.2: Diesel Particulate filter (DPF)

Table 2: Specifications of DPF

Soot generation rate	<0.1 g/h (warm up mode), 2 – 20 g/h
Soot generation	Diesel burner
Fuel compatibility	Diesel fuel, max 10% biodiesel recommended.
Soot rate	20%
Ambient conditions	5 – 40ºC: cooling air inlet temperature -20ºC to 40ºC

3.3 AD BLUE TANK:

Ad Blue is a high quality urea solution that is easy to use. Ad Blue is the registered trademark for AUS32, or Aqueous Urea Solution 32.5% that is used with the Selective Catalytic Reduction system (SCR) to reduce emissions of oxides of nitrogen. The Ad Blue tank is shown in Fig.

Fig 3.3: AD Blue Tank

Used in conjunction with a Selective Catalytic Reduction (SCR) converter, Ad Blue has a profound effect on otherwise difficult to control oxides of nitrogen (NOx) diesel emissions.

On average, NOx emissions are reduced on the order of approximately 80 percent.

IV. EXPERIMENTAL TESTING OF EXHAUST SYSTEM

The exhaust system is tested on the multi gas analyzer and got the satisfactory results when compared with platinum based catalytic converter.

Table 3: Emission table for pure diesel operation

S. No	Load (kg)	CO (% vol)	HC (ppmHex)	CO_2 (%vol)	NOx (ppmVol)
1	0	0.02	14	1	95
2	3	0.02	18	1.6	175
3	6	0.02	24	2.2	302
4	9	0.02	25	2.8	506
5	12	0.02	25	2..7	501

Table 4: Emission table for pure diesel (with DPF+TWC converter connected at the end of exhaust tail pipe)

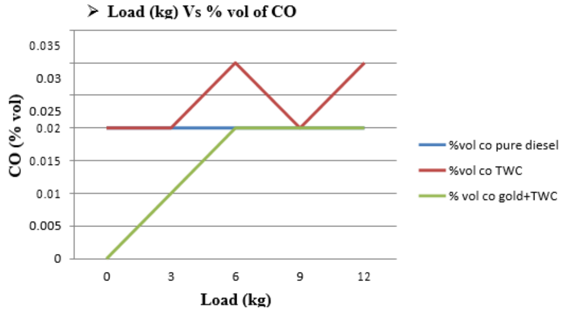
S. no	Load (kg)	CO (%vol)	HC (ppm ex)	CO2 (%vol)	NOx (ppm vol)
1	0	0.02	5	1.5	70
2	3	0.02	28	2.9	290
3	6	0.03	15	3.4	90
4	9	0.02	18	5.3	400
5	12	0.03	20	4.62	350

Table 5: Emission table for pure diesel (with DPF+ gold coated TWC converter connected at the end of exhaust tail pipe)

S. no	Load (kg)	CO (%vol)	HC (ppmhex)	CO2 (%vol)	NOx (ppmvol)
1	0	0.00	3	1.10	44
2	3	0.01	26	2.60	260
3	6	0.02	14	3.20	80
4	9	0.02	13	4.50	339
5	12	0.02	16	5.20	286
6	15	0.02	13	3.20	227

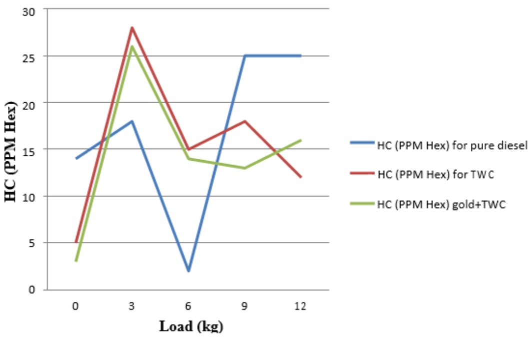
GRAPH:

➢ Load (kg) Vs % vol of CO



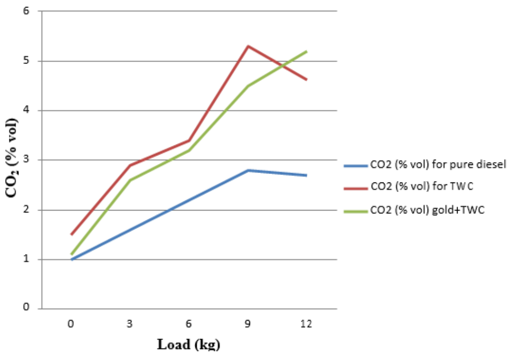
CO emission for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe is lower when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe.

- **Load (kg) Vs HC (PPM Hex)**



HC emission for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe is lower when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe.

- **Load (kg) Vs CO_2 (% vol)**



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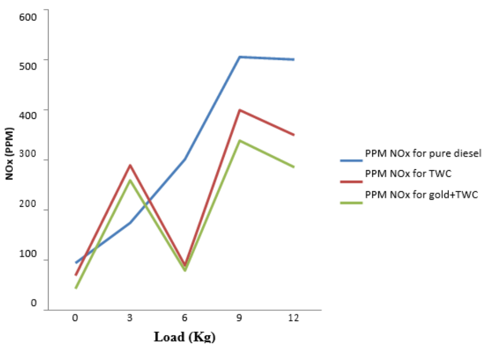
CO2 emission for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe is lower when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe.

- **Load (kg) Vs PPM NOx**



NOx emission for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe is lower when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe.

V. RESULT

Experiments were conducted when the engine was fuelled with pure diesel. The experiment covered a range of loads. The emission characteristics of the engine were observed in terms of concentration of CO, HC, NOx and CO2. The results obtained for with DPF+ Gold based TWC converter +DEF system connected at the end of exhaust tail pipe were compared with DPF+TWC based converter connected at the end of exhaust tail pipe and without connecting catalytic converter at the end of exhaust tail pipe.

VI. CONCLUSION

- CO emission for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe. The CO emission is lower. When compared to the Bharat stage IV Norms for selected engine at all operated loads with retrofit arranged.

- HC emission for DPF+ DEF and Gold based TWC converter system connected at the end of exhaust tail pipe when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe. The HC emission is lower when compared to the Bharat stage IV Norms for selected engine at all operated loads with retrofit arranged.

- Carbon dioxide emission is less for DPF + DEF and Gold based TWC converter system connected at the end of exhaust tail pipe when compared with and without connecting DPF+TWC catalytic converter at the end of exhaust tail pipe.

- Nitrogen oxides / dioxides (NOx) emission is less for DPF + DEF and Gold based TWC converter system when compared with and without DPF+TWC connecting catalytic converter at the end of exhaust tail pipe. The NOx emission is lower when compared to the Bharat stage IV Norms for selected engine at all operated loads with retrofit.

- From the above analysis the main conclusion is DPF + DEF and Gold based TWC converter system is suitable substitute for diesel engine exhaust after-treatment setup as this system produces lesser emission than existing at all loads.

VII. FUTURE SCOPE

In future we can make gold based catalytic converter installed in exhaust system so that the overall cost and concentration of toxic gases coming from exhaust system can be reduced so that the environment will be clean, toxic free and without harmful gases.

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