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Experimental Investigation and Emission Reduction of Nox For Bio Diesel By Using SCR In Di Diesel Engine

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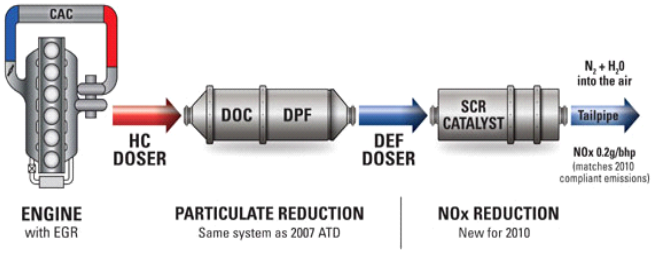
ABSTRACT

Diesel engines are widely used in many areas like automobiles, locomotive marine engines power generations etc., due to its high power output and thermal efficiency. Even though the diesel engines give more benefits, the human discomforts caused by the pollutant emission of these engines have to be considered. The major pollutant emissions of the diesel engines are particulate matters, smoke and the oxides of nitrogen (NOx). Out of these pollutant emissions, the oxides of nitrogen are considered as the most harmful pollutants to the human health. Emissions of nitrogen oxides (NOx) contribute seriously to air pollution, which is a major environmental problem of NOx react with moisture in the air to form nitric acid, contributing to soil and water acidification in sensitive areas. In the after treatment method, urea solution is sprayed in the exhaust stream which is at a temperature of 3000C to 450oC. At this high temperature of exhaust gas, the urea starts to decompose and form ammonia. The ammonia acts as reduction against and converts the oxides of nitrogen (NO and NO2) into free nitrogen (N2) and water vapour (H2O). There are many techniques being tried to control NOx emission from diesel engine. In this project, the emissions controlled by after treatment of exhaust gases. The selective catalytic reduction (SCR) of NOx is a promising technology for NOx reduction.

Keywords: Biodiesel, SCR, DI diesel engine

SELECTIVE CATALYTIC REDUCTION

Selective catalytic reduction systems are the most effective and commonly used post-combustion NOx reduction processes available. SCR utilize a chemical reaction where vaporized ammonia (NH3) is injected, via an ammonia injection grid, into the exhaust gas prior to flowing through catalytic modules. The objective is to convert nitrogen oxides (NOx), to nitrogen and water. The key to optimizing the chemical reaction within the SCR is achieving uniformity of exhaust gas flow rate. Some of the major catalytic industries are Johnson Mathey India Pvt Ltd, Cats Direct, Emitec Emission Controls Private Limited, Automotive Merchandising Corporation, Gencat Limited and Cummins India Limited.



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FORMATION OF NO_X:

NOx emissions do not form in significant amounts until flame temperatures reach 2800 F. Once that threshold is passed, however, any further rise in temperature causes a rapid increase in the rate of NOx formation. NOx production is highest at fuel-to-air combustion ratios of 5–7% O2 (25–45% excess air). Lower excess air levels starve the reaction for oxygen, and higher excess air levels drive down the flame temperature, slowing the rate of reaction.

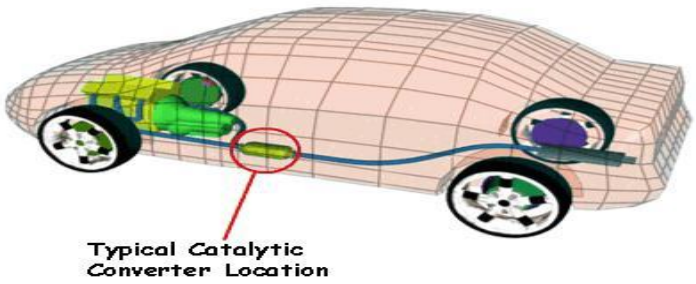
CATALYTIC CONVERTER AS A POLLUTION CONTROLLER DEVICE:

The catalytic converter does a great job at reducing the pollution, but it can still be improved substantially. One of its biggest shortcomings is that it only works at a fairly high temperature. When you start your car cold, the catalytic converter does almost nothing to reduce the pollution in your exhaust.

- **What is catalytic converter?**

As the name suggests, it basically converts harmful gases into harmless gases, which are environment friendly, with the help of a catalyst. Engine exhausts having harmful gases like CO, NOx & HC which are converted into harmless gases like CO2, N2 & H2O respectively with the use of catalytic converter.

POSITION OF CATALYTIC CONVERTER:



Selective Catalytic Reduction (SCR) is a means of converting nitrogen oxides, also referred to as NOx with the aid of a catalyst into diatomic nitrogen, N2, and water, H2O. A gaseous reductant typically anhydrous ammonia, aqueous ammonia or urea, is added to a stream of flue or exhaust gas and is absorbed onto a catalyst. Carbon dioxide, CO2 is a reaction product when urea is used as the reductant. The SCR system does not alter the design of the modern Common Rail Diesel (CRD) engine therefore it can continue to deliver excellent fuel economy and durability. Rather, SCR provides emissions after-treatment well into the exhaust stack, in a way similar to the soot containment achieved by the Diesel Particulate Filter (DPF). SCR works by injecting Diesel Exhaust Fluid (DEF) such as AdBlue, into the hot exhaust stack. DEF works in conjunction with the hot exhaust gases and catalyst to break NOx into two components of our normal atmosphere water vapour and nitrogen.

The second objective is to select the catalyst that is to be coated on the monolithic structure such that it ensures the following,

- The catalyst used must be cheaper than the conventional catalyst, platinum.

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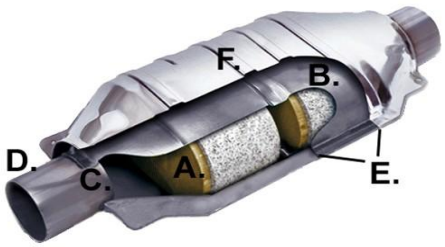
- The catalyst should not be emptied sooner that it requires frequent re-coating.
- The catalyst should not change its physical and chemical properties when subjected to high temperatures, i.e., it should withstand high temperatures.
- The catalyst should enable the above mentioned reactions effectively and efficiently.
- The catalyst must not form any new pollutants during the process as by products.

BASIC COMPONENTS OF SCR:

- **Substrate**: is ceramic honeycomb like structure with thousands of parallel channels that provide a large surface area for the engine exhaust.
- **Wash Coat**: A coating that increases the effective surface area of the substrates & facilitates the application of precious metal catalyst onto the surface of the ceramic surface of the ceramic substrate.
- **Catalyst**: Precious metal catalyst-the heart of catalytic converter, applied to wash coated ceramic substrate.
- **Mat**: It provides thermal insulation & protects against mechanical shock & chassis vibration.
- **Cane:** A metal package that encases all the above components.
- **Heat Shields:** They are used to protect various parts surrounding the catalytic converter, form thermal shocks.

COATING PROCESS:

Catalytic converters are used in automobile and industries for pollution abatement. They usually consist of cordierite ceramic extruded to form a structure of honeycomb-like cells that extend as channels along the catalytic converter length. A paint-like liquid containing the precious metal catalyst is coated on the channel walls.



Ribbing on the shield offers a final layer of protection against heat damage while reinforcing the structural stability of the entire converter. A ribbed body encases the ceramic to reduce expansion and distortion when the converter reaches its high operating temperature. The ribs form channels that hold the ceramic in proper alignment and protect the cushioning mat from direct exposure to exhaust gases.

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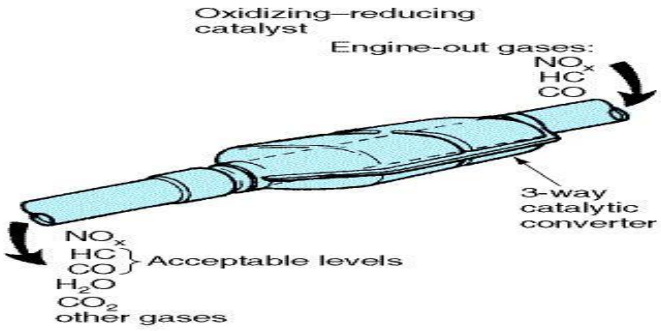
TYPES OF CATALYTIC CONVERTER:

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

In a three-way catalytic converter, the converter is positioned in front of the oxidation catalyst. A three-way catalytic converter reduces NOx emissions as well as CO and HC. The three-way catalyst reduces NOx into nitrogen and oxygen.

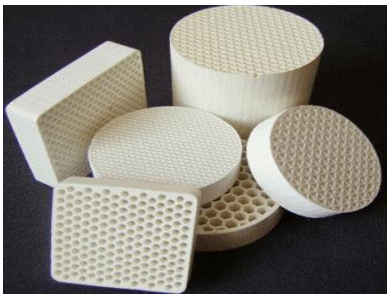


A catalytic is a substance that causes chemical reaction without being changed by the reaction. Noble metals are used as catalysts.

- Oxidation converters: - 70% platinum & 30% palladium is not as efficient as platinum but it is used to reduce overall cost of the unit.
- Reduction converters: - it consists of platinum & rhodium.

A method for producing a ceramic honeycomb structure comprising applying a coating material to an outer peripheral surface of the ceramic honeycomb body to form an outer peripheral wall, the thickness of the coating material applied being determined from the outer diameter of the ceramic honeycomb body and the drying shrinkage ratio of the coating material, such that the outer diameter of the dried ceramic honeycomb structure is within a target outer size ±1.4 mm.

Ceramic Honeycomb structure:



Ceramic Honeycomb

A ceramic honeycomb structure is provided with a plurality of open passages extending there through in an axial direction thereof.

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

For example:

2NO => N2 + O2 or 2NO2 => N2 + 2O2

The Oxidation Catalyst:

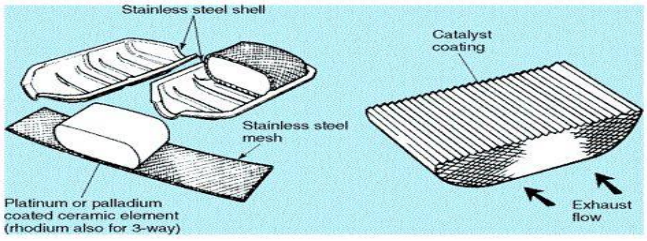
An oxidation catalyst is a flow through exhaust device that contains a honeycomb structure covered with a layer of chemical catalyst. This layer contains small amounts of precious metal-usually platinum or palladium-that interact with and oxidize pollutants in the exhaust stream (CO and unburned HCs), thereby reducing poisonous emissions. Sometimes called an OxyCat when used on a diesel engine, it works together with the DPF and EGR valve to remove the bulk of unburned hydrocarbons, soot and NOx from diesel exhaust.

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:

2CO + O2 => 2CO2

Monolith:



- **Shell**: Manufactures make converter housing of sell of two stamped metal pieces welded to gather to form a round or oval assembly.
- **Monolith**: It is made from ceramic matter. Honeycomb design has hundred of cellular passages for the exhaust gases to floe through.

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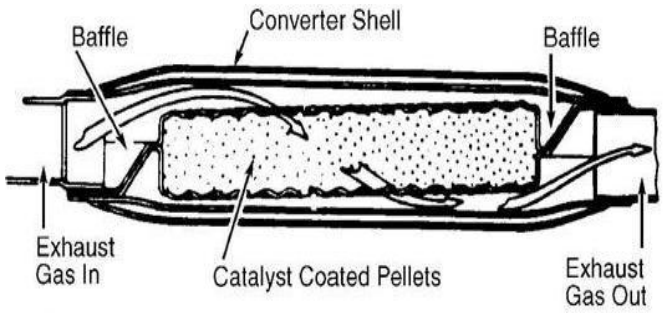
- **Flow diffuser**: It is situated between converter inlet & catalytic element. It is used to obtain uniform flow of exhaust gases over the entire area. If it is not present then pellet type gases will pass through the center of the element only.

Pellet Type:



- **Pellet**: It consists of a small aluminium oxide pellet of 1/8 to 1/10 of an inch in diameter. They are coated with thin layers of platinum or palladium.
- **Baffles:** They direct the flow. First of all gases pass through the upper baffles. They have to pass through the pellets & get out through lower baffles. Baffles support & contains the bed.
- **Insulation**: Situated between inner 7 outer shells. It retarded the transfer of heat so no heat shield is required here.
- **Drain plug**: It permits removal of catalysts pellets with special requirement.

METHODOLOGY

The NOx reduction process starts with an efficient CRD engine design that burns clean Ultra Low Sulphur Diesel (ULSD) and produces inherently lower exhaust emissions exhaust that is already much cleaner due to leaner and more complete combustion.

SCR Catalytic Converter:

In this catalytic converter, zeolites is used to as a conversion agent where the conversion happens. Exhaust gases and an atomized mist of DEF enter the converter simultaneously. Together with the catalyst inside the converter, the mixture undergoes a chemical reaction that produces nitrogen gas and water vapour.

CONTROL DEVICE:

Exhaust gases are monitored via a sensor as they leave the SCR catalyst. Feedback is supplied to the main computer to alter the DEF flow if NOx levels fluctuate beyond acceptable parameters.

CATALYSTS:

SCR catalysts are manufactured from various ceramic materials used as a carrier, such as titanium oxide, and active catalytic components are usually oxides of base metals (such as

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vanadium and tungsten), zeolites, and various precious metals. Each catalyst component has advantages and disadvantages. Some of the major catalytic industries are Johnson Mathey India Pvt Ltd, Cats Direct, Emitec Emission Controls Private Limited, Automotiev Merchandising Corporation, Gencat Limited and Cummins India Limited.

Such as the vanadium and tungsten, lack high thermal durability, but are less expensive and operate very well at the temperature ranges most commonly seen in industrial and utility boiler applications. Thermal durability is particularly important for automotive SCR applications that incorporate the use of a diesel particulate filter with forced regeneration. They also have a high catalyzing potential to oxidize SO2 into SO3, which can be extremely damaging due to its acidic properties.

LOAD in KG	POLLUTANTS %(OR)PPM								
	O_2	CO	X_{AIR}	PI	NO	NO_2	NO_X	SO_2	C_XH_Y
0	10.9	5.546	110	0	35	0	35	0	8
7	6.7	8.649	48	0	35	0	35	0	153
12	5.8	14.269	38	0	38	0	38	8	168
17	9.3	9.144	81	0	51	0	51	25.37	145

Catalytic Converter of This Project:

Inner body placed inside of outer body

EXPERIMENTAL TEST RESULTS:

EMISSION TEST- DIESEL WITH OUT CATALYTIC CONVERTER

EXPERIMENTAL GRAPHS

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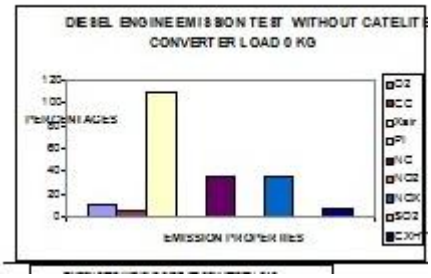

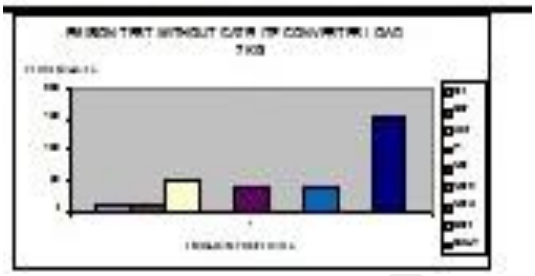

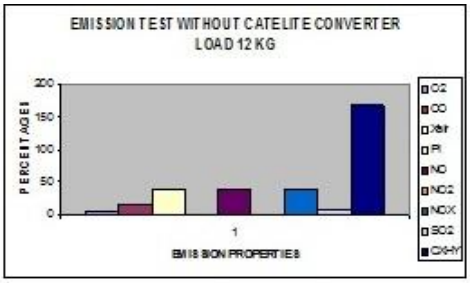

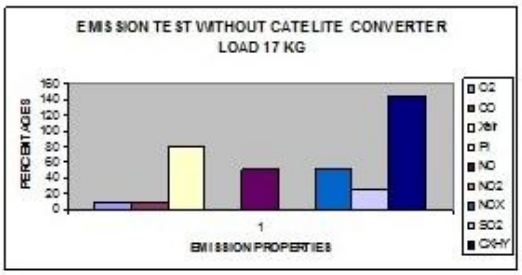

EMISSION TEST- USING CATALYTIC CONVERTER

LOAD IN KG	POLLUTANTS %(OR)PPM								
	O_2	CO	X_{AIR}	PI	NO	NO_2	NO_X	SO_2	C_XH_Y
0	15.4	0.807	28.5	0	12	0	12	58.17	35
7	17.2	1.047	47.2	0	7	0	7	49.46	31
12	20.4	0.273	20	0	1	0	1	13.91	160
17	14.9	1.632	25.3	0	7	0	7	96.17	31

GRAPHS FOR USING CATELITE CONVERTER

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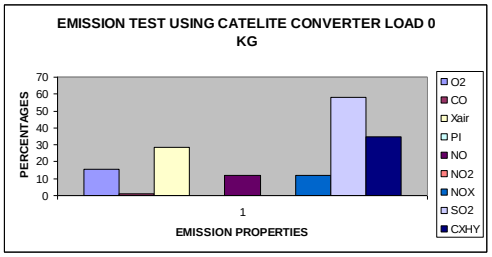

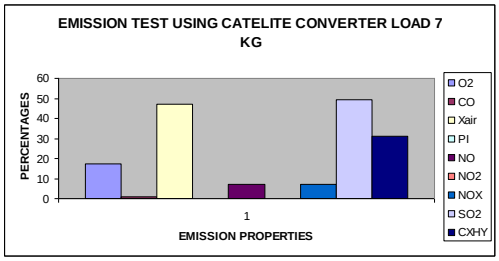

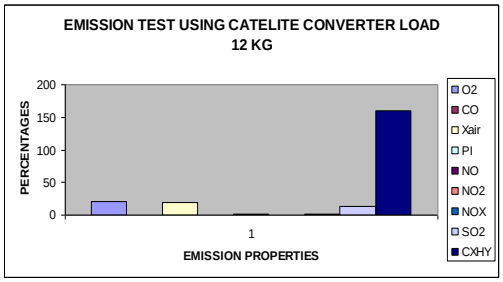

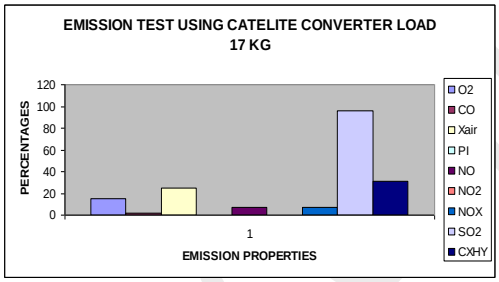

CONCLUSION

By referring through many papers and guidance, the efficiency of selective catalytic reduction can be expected to increase by combination of both urea and zeolites chemical. By increasing the concentration of urea, NOx can be reducing. These can be analyzing by utilizing the various concentration of urea in selective catalytic reduction technology. Zeolites mix with kaoline the binder to increase the separation process. Experimental test carried out due to various loads conditions. The results showed reduction of various exhaust gas not only NOX. If using catalytic converter the most harmful gases should be minimized. Pollution should be controlled. The vehicle performance will be increased.

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