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Devlopment and Perfomance Analysis of Zn/Cu Based Catalytic Converter

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Abstract:*In recent years the growth of automobile has been increase significantly due to the improvement in Technology. This made people's life easier and provided comfort for travelling. Thus due this increase in vehicle on road leads to increase in pollution emitted by vehicle. Major pollutants emitted from automobile, that are harmful to nature are HC, CO and NOx. Hence Catalytic converters are used to deal with these pollutants. Conventional Catalytic converter uses Platinum as a catalyst, which is best suitable catalyst to reduce the pollutants. The concern with the Conventional catalytic converter is the cost of catalyst (i.e. platinum) and availability of catalyst. Hence to deal with above concerns Catalytic converter with Non-noble catalyst such as Zn, Cu is taken into consideration.*

Keywords: *Catalytic converter, Platinum catalyst, Zn Catalyst, Cu Catalyst*

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I. Introduction

Catalytic converter basically is a Tool or a Device that is used to reduce the harmful emission generated from the automobile. Pollutants generated from automobile vehicles are Nitrogen gas, carbon dioxide, Water vapor, Carbon Monoxide, Hydrocarbons and Nitrogen Oxides**.** Out of these pollutants N_2 , CO_2 and H_2 O are not harmful to Environment, whereas CO, NOx, and HC are harmful to the Environment and Living beings. It is estimated that about ⅓ pollution in the air is due to vehicles. Hydrocarbons come out of an engine's exhaust due to unburned fuel, Engine misfire and Bad spark plug**.** CO is produced due to the incomplete combustion. Our study/aim focuses on modification in Conventional catalytic converter by replacing the Noble catalyst with the Non-noble catalyst such as Cu, Zn for cost reduction and easier availability of the catalyst. This Cu/Zn based catalytic converter is to be tested with four stroke single cylinder diesel engine.

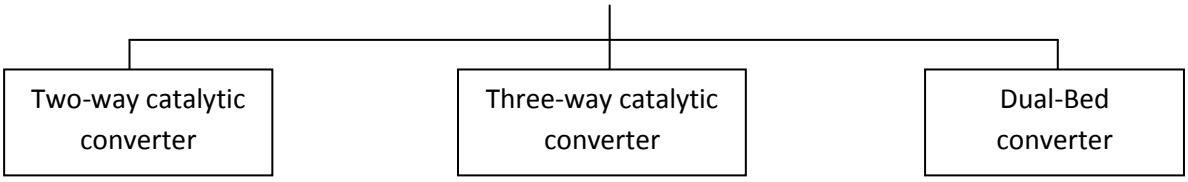
II. Literature survey

1. **Akash Pathak, K. Venkadeshwaran, Alok Kumar Rohit, Niranjan Kumar Naulakha** carried out a research paper that determined the Conventional Catalytic Converter are inadequate/ insufficient to work at very high temperature and are also having High Weight to Volume ratio. It further concerns about the existing catalytic converter create a major back pressure on the engine which is not desirable and they are also not able to meet Euro 6 norms. This research paper determined/found that by applying/using a Cu-Zeolite catalyst wash coat he overcome above problems.
2. **Akash Pathak, K. Venkadeshwaran, Alok Kumar Rohit, Niranjan Kumar Naulakha's** review paper discusses about exhaust gases/emission coming from the Engine such as HC, CO & NOx and its impact and also controlling these Exhaust gases by using noble catalyst (i.e. Platinum) based catalytic converter .This review paper determines that catalytic converters are the best way to control exhaust gases emission. He further described that **"**Three-way catalyst with stoichiometric engine control systems remain the state of art method for simultaneously controlling HC, CO and NOx emissions from vehicle**"**.
3. **A.M.Leman, Afiqah Jajuli, Dafit Feriyanto, Fakhrurrazi Rahman and Supaat Zakaria's** paper aims at reviewing the present development and improvement on the catalytic converter to reduce the exhaust gases emission to meet the Norms and regulation. New catalyst such as Zeolite, nickel oxide and metal oxide are used to replace convectional catalyst like platinum , palladium and rhodium, and these non-noble catalyst effectively reduces the exhaust emission than the commercial converter. The preparation techniques have also been evolved for attaining good characteristics of catalyst. One of the technique is Ultrasonic treatment with combination of electroplating technique, citrate method and Plasma Electrolytic Oxidation.
4. **Chirag Amin, Pravin Rathod's** paper reviewed the existing technologies available to reduce exhaust emission gases coming from automobile engine and exhaust gases coming after treatment from catalytic converter. Various methods to increase the temperature of the catalytic converter during cold starting were

also discussed. Several researches going on to replace noble catalyst like platinum, palladium and rhodium were discussed.

5. **Nadim Bagwan, Sanjay Satpute** review paper throws light on several parameters of catalyst material such as Chemical and Physical property, Efficiency, Cost effectiveness. The materials whose property is similar to noble catalyst such as Pt, Pd and Rh should be considered for its material availability and cost effectiveness. The characterization methods are important as it impart certain properties on the catalyst materials so that the catalyst will be able to perform better in emission performance.
6. **Nitin Rathod, Rohan Panage, Prof. W. S. Rathod** research paper focuses on using catalyst materials of non-noble metals with nano-particles to study the emission performance of the engine at various loads and speeds. Ruthenium catalyst was used with combination of Platinum catalyst. Here the catalyst is prepared by Sol-Gel method under Argon using dry solvents. This research paper concludes that Ruthenium catalyst produced/provided good result when used as a oxidation catalyst. It reduced HC emission 3.66 to 56.58% and CO emissions by12.66 to 63.67 %. However it was not capable to control NOx emission. Hence it was good oxidation catalyst but another reduction catalyst is to be used with ruthenium catalyst, to control NOx emission.
7. **Manishkumar parmar, piyush patel, aarshveek Mehta's** review paper discusses about various types of low cost Catalyst materials like copper, nickel that can be used in a catalytic converter. It also deals with exhaust emission coming out of a catalytic converter and also its effect on the performance of the engine such as Conversion efficiency, Activeness of catalyst at lower temperature (i.e. cold starting of automobile).
8. **Vishal Gupta, Krithnarth Chaturvedi, Mayank Dubey, Dr. N. M. Rao 's** review paper discusses about the conventional catalytic converter with platinum as the catalyst and its ability to reduce the Automotive Exhaust Emission and Advancement of the catalytic converter in future and there capabilities to reduce the emission . It also throws light on some of the Limitation of Conventional catalytic converter such as Low temperature working of Catalytic Converter. This review paper states that 3-way catalytic converter with stoichiometric engine control system is the best advancement till date.
9. **Jay M. parmar, Prof. Keyur Tandel** carried out a research paper by replacing platinum catalyst in Catalytic converter by Limestone as a catalyst. This paper includes several investigation/Experimentation in various parameters such as flow characteristics, Temperature distribution and conversion efficiency. This paper concluded that Catalytic converter with limestone catalyst showed Good and effective result in terms of reducing Exhaust emission and also in working conditions.
10. **Grigorios C. Koltsakis, Anastasios M. Stamatelos** review paper studied the existing/current technologies for reducing the exhaust emission from automotive. This study suggests a combination of an advance lean NOx catalyst with a particulate filter for reduction of NOx emissions from automotive. It also suggests a lean burn Otto engines for reducing NOx emissions in Petrol engines.

III. Types



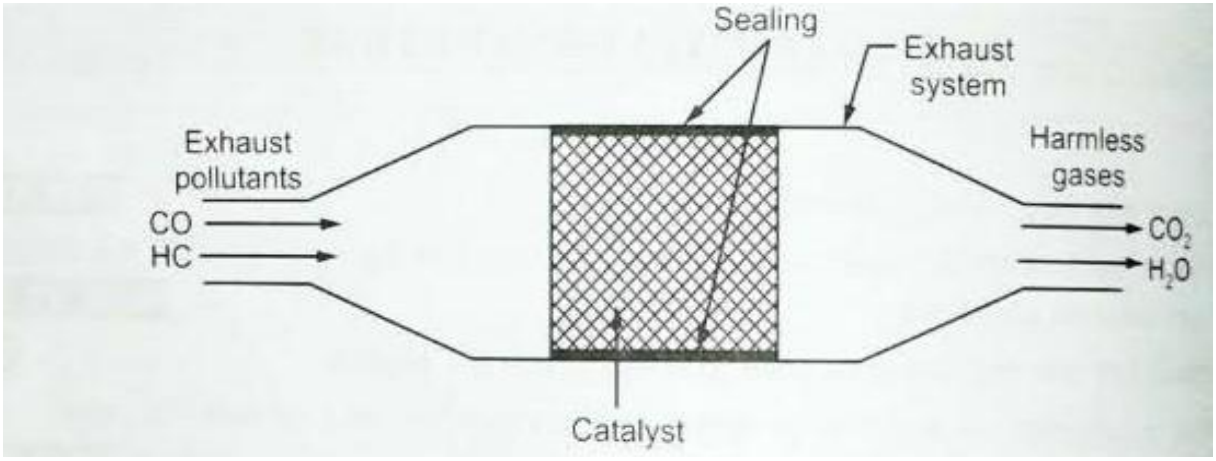
1. **Two-way Catalytic converter**: A Two-way catalytic converter performs two tasks simultaneously.
    a. Oxidation of carbon monoxide to carbon dioxide:

$$2CO + O_2 \rightarrow 2CO_2$$

    b. Oxidation of unburnt hydrocarbon to carbon dioxide and water:

$$CxH2x+2 + 2xO_2 \rightarrow xCO_2 + 2xH_2O$$

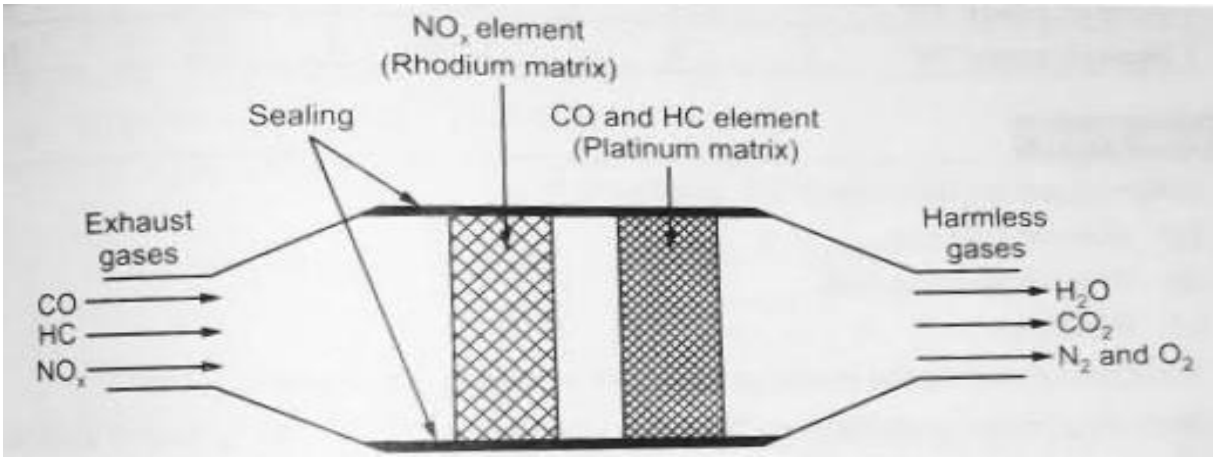
A two-way catalytic converter is widely used in diesel engines for reducing Carbon monoxide and Hydrocarbons. The demerit of a two-way Catalytic converter is that it cannot reduce the NOx emissions.



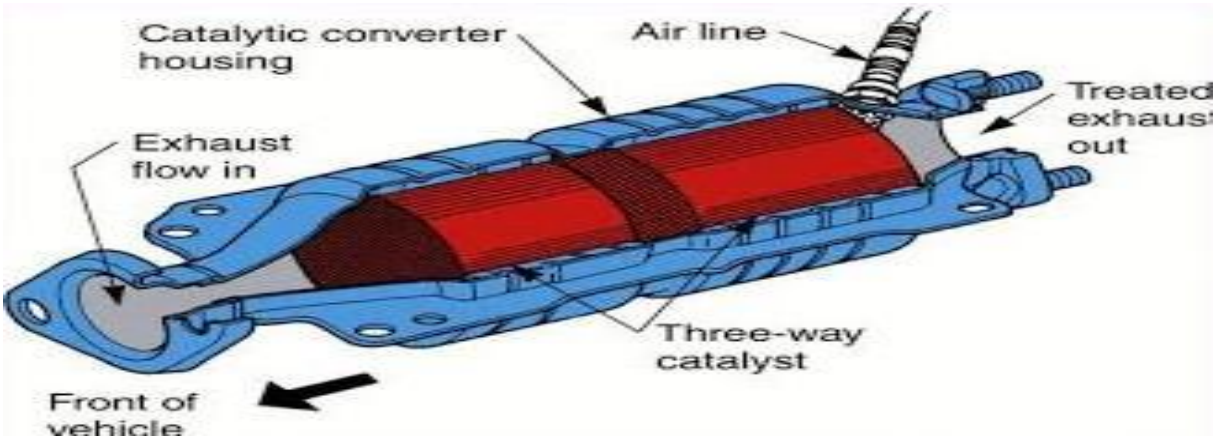
2. **Three-way Catalytic converter:** Three-way catalytic converter treats Carbon monoxide and unburnt hydrocarbon similarly as Two-way catalytic converter. Additionally , Here reduction of nitrogen oxides to nitrogen and oxygen also take place**:**

2NOx → xO2 + N2

A Three-way catalytic converter is widely used in petrol engines cars. The merit of a Three-way catalytic converter over a two-way catalytic converter is that it reduces the NOx emission coming from Exhaust pollutants.



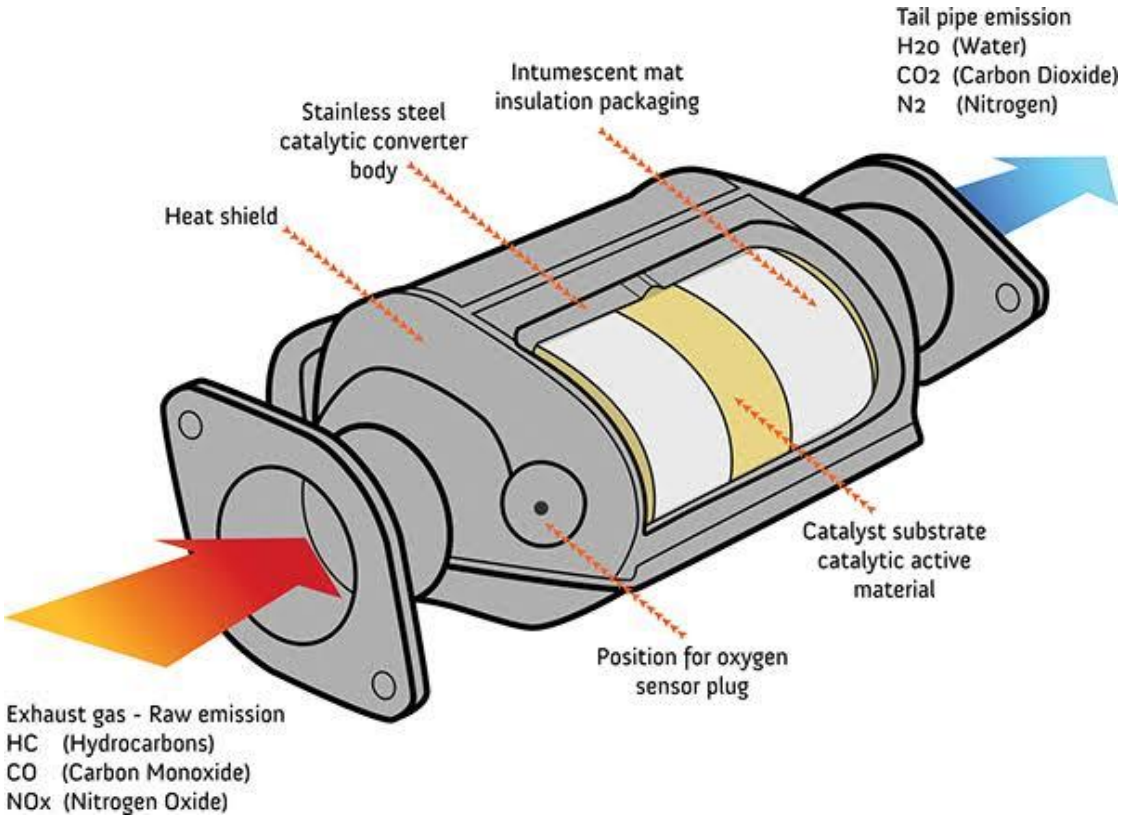
3. **Dual bed Catalytic converter:** A dual bed catalytic converter is combination of a two-way and a three-way catalytic converter combined in a single housing with a air chamber between them. The exhaust gases are firstly reduced to remove NOx emission from the exhaust gases and then these exhaust gases passes through the air chamber present between them. Here, sufficient amount of air is added for the oxidation of HC and CO present in exhaust gases.



IV. Construction

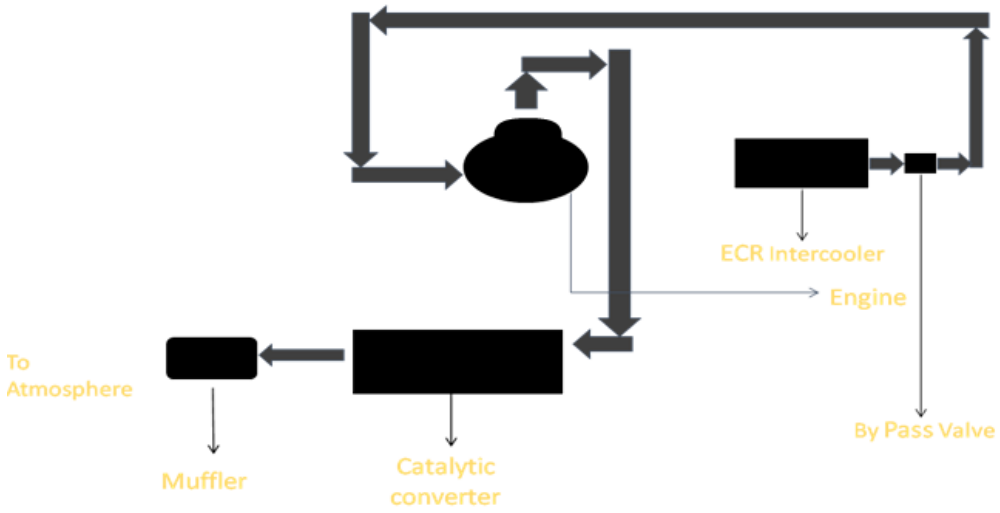
The main component of catalytic converter is Catalysts, Substrate and Outer housing**:**

- **Catalyst:** The catalyst increases the rate of reaction (i.e. oxidation and reduction) without being consumed itself. Conventional catalytic converter consists of platinum, palladium and rhodium catalysts. Platinum and rhodium are used as reduction catalyst, whereas Platinum and palladium are used as reduction catalysts.
- **Substrate:** Catalytic converters require large surface area for better reaction between catalyst and Exhaust gases. Hence to deal with this ceramic substrate with honeycomb structure is used for better reaction between Exhaust gases and Catalysts.
- **Outer housing:** Outer housing is generally made of Stainless steel with appropriate insulating material because during reaction between Exhaust gases and Catalyst temperature reaches upto 1200^0 F. The outer housing also provides various mounts for connections. One end is connected to exhaust manifold and other end is connected to exhaust pipe which is further connected to muffler.



V. Working

The exhaust gases generated from engine enters to catalytic converter through exhaust manifold. The flowchart of exhaust gases is as shown below:



The exhaust gas enters into the catalytic converter where it firstly reacts with a reduction honeycomb substrate which is coated by platinum and rhodium catalyst. Here harmful NOx emission in converted into nitrogen and oxygen which are not harmful to nature. Now these exhaust gases further reacts with oxidation honeycomb substrate which is coated with platinum and palladium catalysts. Here harmful HC and CO are concerted in less harmful water vapor and carbon dioxide.

VI. Merits and De-merits

- **Merits :**
  - It converts harmful exhaust emission gases to less harmful emission gases for the nature and living beings.
  - Numbers of vehicles are increasing day by day, as a result, the pollution coming from these vehicles will also increase, hence catalytic converter reduces these harmful emissions by significant amount.
- **De-merits :**
  - The overall cost of a vehicle will increase, as catalytic converters are expensive.
  - There will be loss in power (i.e. 1% of less horsepower)
  - It will affect the fuel efficiency of the vehicle.
  - It will create back-pressure on the engine.

VII. Conclusion

Catalytic converters are the best way to reduce the exhaust emissions. There are several other techniques to reduce emissions, but they are not as efficient and as effective as Catalytic converters. Obviously, in future the number of automobiles will be increased and as a result pollutants coming from them will also increase, so catalytic converter becomes necessity. Hence due these concerns most of countries have implemented various norms such as Bharat stage, Euro norms. Convectional catalytic converters have Platinum, Palladium and rhodium catalyst to reduce the HC, CO and NOx emissions. The problem with this catalyst is there availability because these catalysts are precious and are available in less quantity. Also the cost of such catalyst is high, they cost about 2% of total cost of car. Also this noble catalyst gets active at high temperature, as a result during cold starting of vehicle catalytic converters do not work for few moments. To deal with above concerns we replace noble catalyst with non-noble catalyst such as Zinc/Copper. These catalysts are available in abundance and also cost significantly low as compared to noble catalysts. The selection criteria for non-noble catalyst are Availability, Cost, Material strength, Rate of oxidation and Electroplating of selected material on substrate. Hence **Zinc** and **Copper** material are selected as a catalyst that follows above all criteria.

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