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7. Analysis of C.I Engine by Using Zirconium Dioxide Coated Wire Mesh Catalytic Converter

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ABSTRACT:

One of the hottest topics in automotive research right now is how to reduce emissions from vehicles. These noble metal-based catalytic converters were once scarce and expensive, but now they are widely available. Ultra-low emission vehicles must be produced at a fair cost by the automotive industry. The purpose of this research is to examine the efficiency of fabrication procedures for modified catalytic converters. Palladium, Rhodium, and Palladium are the most widely utilised catalysts in convertors. Despite platinum's widespread use and high activity as a catalyst, the metal is quite pricey. Palladium is a catalyst for oxidation, while Rhodium is a catalyst for reduction. Because of the high cost of these components, the catalytic converter's price rises. As a result, the project's goal is to find the most cost-effective way to improve the efficiency of catalytic converters.

KEYWORD:

C.I. Engine, Zirconium dioxide, catalytic, mesh wire, Zr02.

Introduction:

Even though automobiles have made our lives easier and more comfortable by allowing us to go around more quickly, they also make our lives more complicated and vulnerable to the hazardous fumes they produce, as well as to the increased chance of accidents. Combustion of fuel in air is the most essential chemical reaction in a petrol and diesel engine because it produces the energy needed to move the vehicle. Carbon dioxide and steam would be the only byproducts of burning in a perfect scenario. [1]

In practise, the complete oxidation of the fuel is dependent on a number of factors: first, there must be sufficient oxygen; second, there must be adequate mixing of the petrol and

air; and finally, there must be sufficient time for the mixture to react at high temperature before the gases are cooled. Because of the engine's cycle, the amount of time available for combustion is extremely short in internal combustion engines. This results in the partial oxidation product, carbon monoxide (CO), as well as a wide range of volatile organic compounds (VOCs), such as hydrocarbons (HC), aromatics, and oxygenated species (O2). [2]

The engine produces a variety of incomplete combustion products, including as CO, HC, NOx, and particulate matter, as a result of the incomplete combustion process. All three of these pollutants are bad for us and the ecosystem, which is why the EPA sets such strict standards for pollutant emissions. Engine emissions can be reduced using a variety of alternative technologies, such as better engine design, pre-treatment of the fuel, the use of different types of fuels, additives in the gasoline, and exhaust treatment, among others. Catalytic converters have proven to be the most effective method of reducing emissions from motor vehicles so far. [3]

A catalysed redox reaction transforms harmful pollutants in exhaust gases into less harmful ones via the use of a catalytic converter in a vehicle (oxidation or reduction). Internal combustion engines, particularly lean-burn engines that run on petrol (gasoline) or diesel require catalytic converters. Eugene Houdry, a French mechanical engineer and expert in catalytic oil refining, invented the catalytic converter in the 1950s while living in the United States. [4]

There are a number of ways to reduce emissions from a vehicle's exhaust,

1. exhaust gas recirculation (EGR)
2. positive crankcase ventilation (PCV)
3. catalytic converter

A catalytic converter modification has been made, and the zirconium dioxide powder coated wire mesh shown in Fig. 1. [5]

Fig. 1 Old catalytic converter Coated wire mesh

Review of Literature:

V.Veeraragavan [6], An attempt was made in his work to investigate the performance of various metal oxide catalysts in the combustion of carbon monoxide and the tri metal oxide catalyst in decreasing pollution from four-stroke C.I engines. There was an experimental discovery of a long-lasting catalyst that could be useful in the future.

Krunal P. Shah [7], During his research, he studied several papers related to zirconium dioxide coating in catalytic converters and the wire mesh structure effect in the catalytic converter instead of honeycomb structure also found their effect on the performance of the I.C. engine in his study. For this project, a compression ignition engine's catalytic converter will be used with a new catalyst to reduce pollution. Hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxides are the main topics of discussion. It's a catalyst for the wire mesh to be created. It has been coated with zirconium dioxide on the wire mesh (ZrO2). Conventional catalysts (noble metals) such as platinum and palladium are expensive compared to the newer materials. Carbon dioxide (CO2) and water (H2O) are produced as byproducts of the catalytic converter, which reduces emissions.

M AKalam [8], A low-cost three-way catalytic converter is being created in this study for use with the newly built CNG-DI engine. We've given and discussed a comprehensive review of catalytic converters, as well as the characteristics of low-cost catalytic converter development.

P. V. Walke, N. V. Deshpande (2011) [9] research on "Cost effective diesel engine after treatment catalytic converter" is being done, this study provides a cost-effective diesel engine catalytic converter (CAT). Catalyst compounds, such as Cerium Oxide (CeO2), Zirconium dioxide (ZrO2), silver nitrate (AgNO3), and copper nitrate (Cu(NO3)2), were used to build the CAT, which is based on these materials. When compared to noble metals like palladium and platinum, these catalyst materials are affordable.

Chirag M. Amin, Prof. Pravin P. Rathod, Prof. Jigish M. Goswami (2011) [10] "Copper-based catalytic converter" is the topic of this study. Hydrocarbon (HC), Carbon Monoxide (CO), and Nitrogen Oxide (NOx) exhaust emissions from automobiles are of particular importance. In the exhaust system, dangerous CO and HC emissions are oxidized to CO2 and H2O by the catalytic converter, which reduces emissions. Catalytic converters based on noble metals are susceptible to a variety of issues. A catalyst based on non-noble metals, such as copper, may be more readily improved to exhibit the appropriate activity and to have longer-lasting properties due to the metal's resistance to toxicity.

The study was performed by Krunal P. Shah and Dr. Pravin P. Rathod. [11] Catalytic converters can use a variety of metal oxides as catalysts, according to a new study. Copper Oxide, Cerium Oxide, and Zirconium Dioxide are among the metal oxides in use. When making the comparison, the rpm was kept constant. Cerium Oxide was found to be the most effective of the metal oxides catalysts tested. Despite its name, zirconium dioxide is the worst catalyst. When compared to other catalysts, zirconium dioxide and cerium oxide have the highest smoke opacity. The increased surface contact area provided by the wire mesh structure translates into improved efficiency.

Objectives:

- To study automobile exhaust emission and how it must be controlled
- To study schematic and role of catalytic converter
- To study oxidation and reduction Process in Catalytic Converter
- To study how engine efficiency increases by using zirconium dioxide coated wire mesh

Research Methodology:

Research is a voyage of discovery; a journey; an attitude; an experience; a method of critical thinking; an activity caused by instinct of inquisitiveness to gain fresh insight/find answers to question/acquire knowledge. This research analyzes and reviewing various reports on the learning and research related to the topics.. The journals were obtained from the online databases, focusing on journals. On the topic , the identification was focused on the material, the participants, and learning methods used in the study. For the papers about research, the identification was focused on the objects, methods, and results, and the accuracy of the classification methods used. The results of the analysis were then prepared and used as material for a systematic review about the learning and research in the topics.

Result and Discussion:

A ceramic honeycomb or metallic matrix is the predominant monolithic structure employed today in most catalytic converters. The exhaust gas flows through several channels in a monolith, which has a high flow rate [12]. Figure 2 depicts the schematic conversion of Three Way Catalyst (TWC) in which the most common form of catalytic converter is employed.

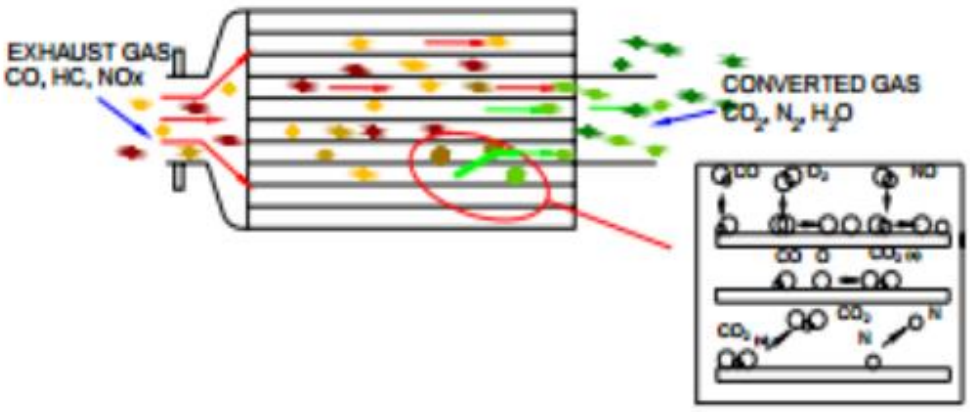

Fig. 2 Schematic of a three way catalyst converter

Catalytic converter feed gases include HC, CO, NOx, and CO2 from the exhaust port of the engine. Two chemical reactions, such as catalytic reduction and catalytic oxidation, take place in the catalytic converter. Nitrogen oxide is reduced to pure nitrogen in the catalytic reduction process. [13] CO2 emissions are formed as a result of the free oxygen reacting

with CO. Hydrocarbons and carbon monoxide continue to burn during the oxidation process. Hydrocarbons and carbon monoxide can only be formed if there is enough oxygen in the atmosphere. Carbon monoxide and hydrocarbons are oxidized in this chemical process, resulting in carbon dioxide and water as byproducts. Figure 3 depicts the details of catalytic reduction and oxidation. [14]

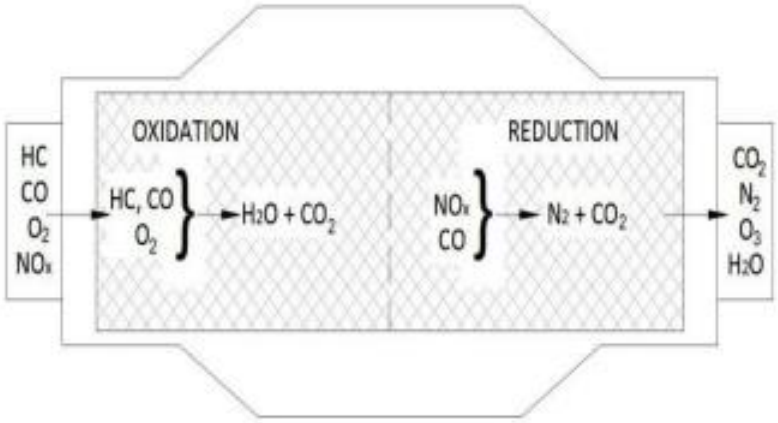

Fig. 3 Oxidation and Reduction Process in Catalytic Converter

Catalysts made of zirconium dioxide minimize HC emissions. CO emissions are reduced by all three catalysts (zirconium dioxide, cerium oxide, and copper oxide). ZnO and CeO (zirconium dioxide + cerium oxide) are used as a catalyst to decrease NOx emissions Thermal efficiency of a brake is reduced with time. The catalyst converter [15]

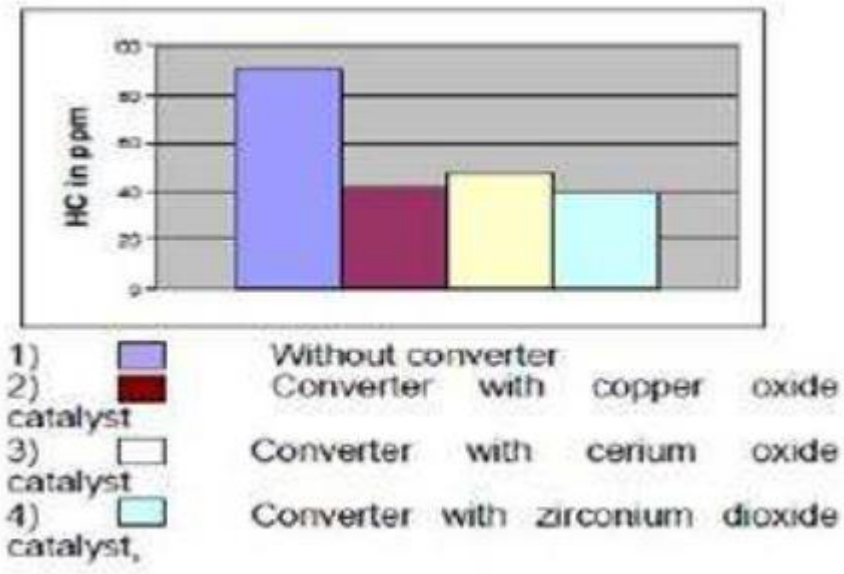

Fig. 4 Comparison of HC emission (Constant RPM 1500)

Engine shaft RPMs were manually increased from 1500 to 6000 at 1500 intervals. At RPMs 1500, 3000 and 4500, the exhaust gas temperature rose by 121 ° C., 257 ° C, 284 ° C, and 391 ° C respectively.

In the instance of NOX, the maximum conversion efficiency was observed at 6000 RPMs, which demonstrated a 75% efficiency for NOX reduction shown in Fig 5. [16-17] It is due to the lack of moisture content at high temperatures that zirconia promoted catalysts have the best efficiency.

The poisoning of catalysts is reduced when the temperature reaches beyond 300 °C, thereby providing more reaction sites. [18]

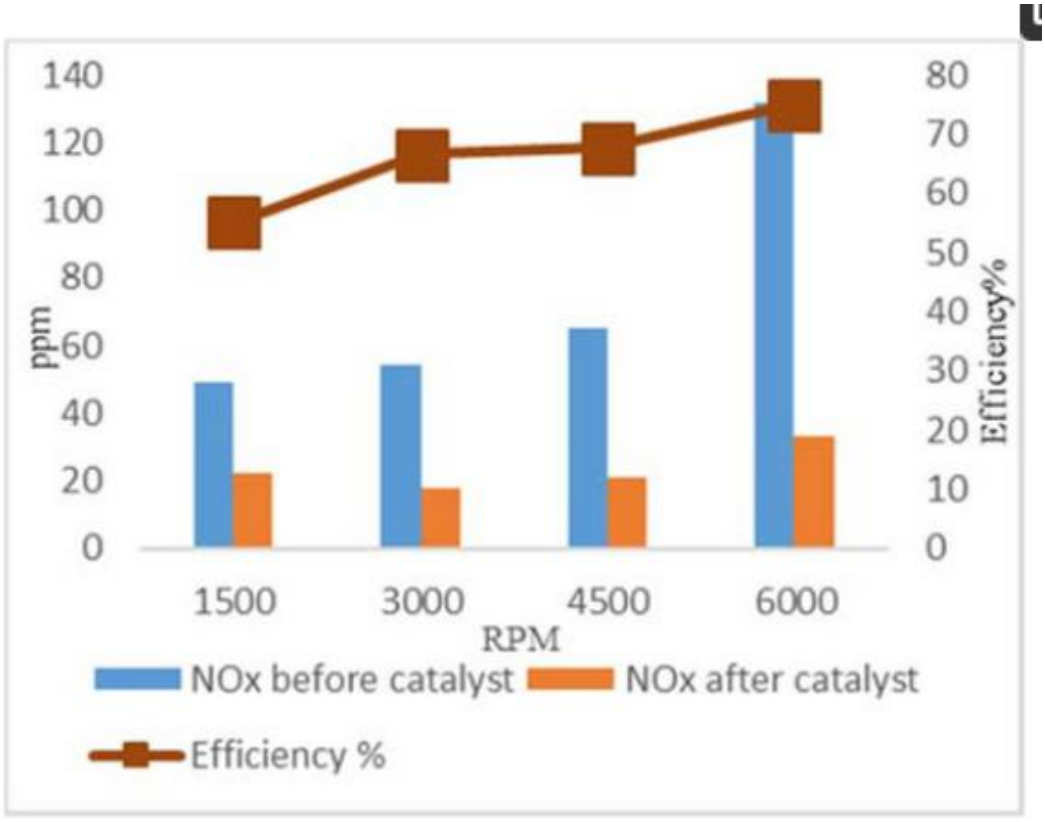

Fig. 5 Conversion of NOX with 8 wt.% ZrO2-Co3O4/TiO2.

Active site HC, CO and NOx conversion is further influenced by the ZrO2-based catalysts' overall basicity and acidity.

ZrO2's Lewis acidic sites are Zr4+ species, while its Lewis basic sites are O-2 species. Catalytic reactions were depicted in Fig. 6 as follows: [19-20]

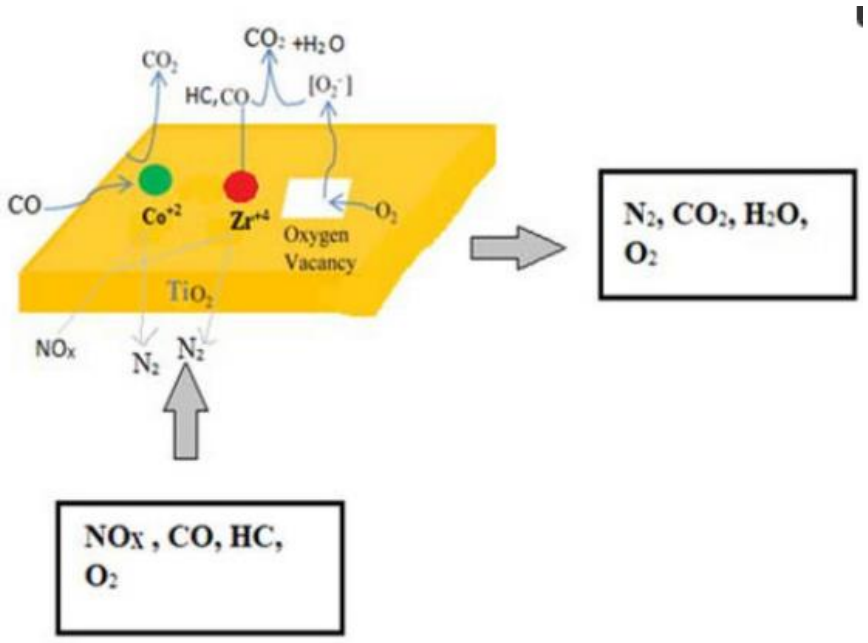

Fig. 6 Conversions of NOx, CO, HC to N2, CO2, and H2O on 8 wt.% ZrO2-Co3O4/TiO2

Conclusion:

While platinum, palladium and rhodium are extensively used catalysts because they are very active, they are also expensive. Manganese-coated copper, zirconium dioxide, cerium oxide and copper oxide can be used as catalysts instead of the typical noble metals. There was a lot of satisfaction with the exhaust emission outcomes that were produced. As the temperature rose, so did the power of the brakes. Engine emissions were much improved as a result of the employment of these materials. Furthermore, the fact that these materials are significantly less expensive than noble metals can be overlooked. By using an effective catalytic converter, pollution reduction can be done at the lowest possible cost. ZrO2 coated wire mesh catalytic converters' highest performance was achieved at an optimal temperature. A study was conducted to determine the impact of wire mesh on brake-specific fuel consumption as well as brake thermal efficiency. Catalytic converter back pressure is measured by varying the number of wire mesh in the converter.

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