Experimental Analysis using an Innovative Catalytic Converter coated with Nano-particles for Pollution Control from Automobiles

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Abstract. Air pollution control has become the area of interest due to the ever increasing air pollution problem from the automobiles. Several researchers have conducted several experiments to control the air pollution concentration from automobiles by using several techniques but this area has a wide scope for improvement. This research paper is based on an experiment conducted on a Four Stroke Spark Ignition engine test rig using an Innovative catalytic converter which was coated with nano-particles to estimate its effectiveness in air pollution control. The results of the experiment conducted clearly indicate that the Innovative design of catalytic converter is effective in air pollution control from automobiles.

Keywords. Automobiles, catalytic converter, nano-particles, pollution.

1. Introduction
Glencross et al. [1] described that the air pollutants are very dangerous to the immune system of human beings. Air pollutants can disrupt the immune response and trigger health issues. So, the air pollutants should be treated so that they do not create health problems for human beings.

Fattorini et al. [2] analysed the role of air pollutants in the spread of the novel corona virus in Italy. They described that the presence of air pollutants in large concentrations in an area is harmful and can aid in spreading of the Covid disease causing breathing problems. So, control of air pollutants is necessary to ensure the availability of clean and pollution free breathing air for all human beings.

Twigg [3] described that the oxidation of the exhaust emissions emitted from the tail pipe of automobiles by a suitable catalyst can be very helpful in decreasing their concentration. The catalyst which is coated on the surface of a suitable catalytic converter aids the reaction between the exhaust emissions and oxygen thereby converting the Carbon monoxide (CO) and Hydrocarbons (HC) in to Carbon dioxide (CO₂) and water vapour.
Dey and Dhal [4] proposed a method for control of Carbon monoxide (CO) concentration from exhaust of automobiles using catalytic converter coated with Copper oxide catalyst. The results of the method depicted that the concentration of air pollutants from automobiles can be decreased by using a suitable catalyst on the surface of a catalytic converter.

Feldheim et al. [5] elaborated the advances in the synthesis, characterization and applications of nano-particles in different areas. They described that nano-particles have evolved as an innovative technology for an effective solution of various prevalent problems, one of them being the air pollution and its control. Metal nano-particles have superior properties compared to other bulk materials mainly due to their active surface area which is very helpful for reducing the exhaust emissions concentrations emitted from automobiles.

Kishore and Krishna [6] performed experiments for determination of exhaust emissions concentrations from Copper coated Spark Ignition engine using a blended fuel. From the exhaustive experimentation, they demonstrated that use of copper may be very helpful in controlling the concentrations of harmful exhaust emissions. Since, copper is cheap and easily available, so, it is an excellent option to be used in the control of exhaust emissions concentrations emitted from the Spark Ignition engine automobiles.

Heiter et al. [7] conducted an experimental investigation for determination of exhaust emissions from automobiles using methyl esters. From the experimental results, it was evident that if some treatment methodology is used for reducing the exhaust emissions concentrations, it would lead to a cleaner and greener atmosphere.

Murali et al [8] conducted a comparative analysis on the use of a Copper coated catalytic converter for controlling the exhaust emissions concentrations from a Two Stroke and Four Stroke Spark Ignition engine. From the results of the experimental analysis, it was clear that Copper coated catalytic converter is very helpful in control of exhaust emissions from Spark Ignition engine automobiles.

Dey and Mehta [9] presented a detailed investigation on control of exhaust emissions from automobiles using metal catalyst. They explained that the metal catalysts are very effective in controlling the concentration of harmful exhaust emissions from the automobiles. So, metal catalyst can be employed in the catalytic converters of automobiles and that will result in a cleaner environment.

Dey and Dhal [10] presented an experimental study on controlling the harmful exhaust emissions from automobiles using the copper oxide catalysts on a catalytic converter. They explained that this method would be very effective to keep a check on the concentration of Carbon Monoxide emitted from the automobiles. The reason for the superior performance of Copper oxide catalysts are their superior properties which are very helpful to convert the harmful Carbon Monoxide in to Carbon dioxide.

Metal nano-catalysts are being used in automobile emission control systems and in other pollution control and treatment applications to facilitate petroleum extraction and production and to produce chemicals and chemical products. Catalysts usually have two principal roles in nano-technology areas: (i) In macro quantities, they can be involved in some processes for the preparation of a variety of other nano-structures like quantum dots, nano-tubes, etc. (ii) Some nano-structures themselves can serve as catalysts for certain chemical reactions.
2. Experimentation
The experimentation for evaluation of the utility of an innovative catalytic converter in the control of air pollution from automobiles consists of several steps. They are as follows:

2.1. Design and Fabrication of an Innovative Catalytic Converter
In the first step, a design of the catalytic converter named as “Innovative design” was prepared. The design was prepared according to the design recommendations. Thereafter, an innovative catalytic converter was fabricated on the basis of the design.
Figure 1. Innovative Catalytic Converter
2.2. Selection of a Four Stroke Spark Ignition Test Rig

In the second step, a suitable Four Stroke Spark Ignition engine test rig was selected for experimentation.

![Diagram of Four Stroke Spark Ignition Engine test rig](image)

**Figure 2.** Four Stroke Spark Ignition Engine test rig

After selection of the test rig, the fabricated catalytic converter was coated with Copper nano-particles using drop casting method. The heat treatment was carried out using a muffle furnace.

![Image of muffle furnace](image)

**Figure 3.** Heat treatment in muffle furnace
The specifications of the muffle furnace are as follows:

| Specification                        | Details                                                                 |
|--------------------------------------|-------------------------------------------------------------------------|
| Inside Chamber Size                  | 150 x 150 x 149mm (6" x 6" x 6"), 3.6L                                  |
| Standard Working Temperature         | 1600° C (continuous)                                                    |
| Maximum Working Temperature          | 1700° C (< 1 hours)                                                     |
| Heating Rate                         | 0 ~20 °C/min (≤10°C/min recommended)                                    |
| Temperature Accuracy                 | +/- 1° C                                                                |

Then, the experiment for measurement of exhaust emissions before and after using catalytic converter was conducted. A multi gas analyzer was used for measurement of exhaust emissions concentration.

![Multi gas analyzer](image)

Figure 4. Multi gas analyzer

The specifications of NPM MGA 2 gas analyzer are as follows:

| Specification                        | Details                                                                 |
|--------------------------------------|-------------------------------------------------------------------------|
| Model Name/Number                    | NPM-MGA-2                                                               |
| Brand                                | NETEL                                                                  |
| Usage/Application                    | VEHICLE POLLUTION TESTING                                              |
| Product Type                         | MULTIGAS ANALYZER                                                      |
| Power Supply                         | 12 DC and 230V AC                                                      |
| Analysis Time                        | Quick                                                                  |
| Color                                | Gray                                                                   |
| Automation Grade                     | Automatic                                                              |
| Country of Origin                    | Made in India                                                          |
The experimental procedure is as follows:
Connect the instrumentation power input plug to a 230 V, 50 Hz single phase AC supply. Now all the digital meters namely, rpm indicator, temperature indicator display the respective readings. Fill up the petrol to the fuel tank mounted side of the panel. Check the lubricating oil level in the oil sump. Start the engine with the help of given attachments. Allow the engine to stabilize the speed, i.e., 1500 rpm to 2200 rpm by adjusting the accelerator. Apply ¼ load, i.e. slowly vary the load attachment.
Note down all the required parameters mentioned below:
(a) Speed of the engine in rpm.
(b) Load from spring balance.
(c) Time taken for 10 cc of fuel consumption.
(d) Manometer readings.
Then, Load the engine step by step with the use of load attachment such as,
(a) \( \frac{1}{4} \) load
(b) \( \frac{1}{2} \) load
(c) \( \frac{3}{4} \) load
(d) Full load

3. Results and Discussion
After conduction of the experiment, the exhaust emissions concentrations were compared before and after using the innovative design catalytic converter. The comparison is shown in the following figures:

![Variation of CO with Load at 1500 rpm](image)

**Figure 5.** CO percentage Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 1500 RPM
Figure 6. HC PPM Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 1500 RPM

Figure 7. CO percentage Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 1800 RPM
**Figure 8.** HC PPM Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 1800 RPM

**Figure 9.** CO percentage Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 2000 RPM
**Figure 10.** HC PPM Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 2000 RPM

**Figure 11.** CO percentage Without Catalytic Converter (WOCC) and With Catalytic Converter (WCC) at 2200 RPM
4. Conclusion
This research paper highlights the use of an innovative catalytic converter coated with nano-particles for pollution control from Spark Ignition engine automobiles. From the results, it is evident that the proposed method is effective for pollution control from Spark Ignition engine automobiles. This research paper also highlights the use of Copper as an effective option for use in catalytic converter. Since, the proposed approach in this research paper is based on the Post pollution control, so, it is easy for implementation in automobiles and cheaper as compared to design modification based methods.

The idea behind the work is to create a structure that exposes the maximum surface area of catalyst to exhaust stream, also minimizing the amount of catalyst required. The exhaust gases pass through a bed of catalyst and the catalytic action takes place at surface of copper which are porous and the higher catalytic activity towards the oxidation of CO and HC could be due to the higher catalytic surface area of small nano-particles. The proposed method is very effective in the prevention of environmental pollution contributed from two-wheeler automobiles. It involves the use of copper nano-particle that is cheaper than the platinum, palladium and rhodium nano-particles used in automobiles.

In the current scenario, the pollution control is a crucial area for research and development. Lots of work has been done by the researchers in this connection, but the area is still lacking for an efficient technique which can provide highly robust emission control for all the operating conditions of vehicles. This research work opens a gateway to study the changes in the concentration of exhaust emissions due to the nano-material copper coating. The modeling will help in understanding the mathematical nature of the process and simulation will help in predicting the results with ease.
5. References

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