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Emission Control of Catalytic Converter Using Cerium Oxide (CeO) and Cobalt Oxide (CoO) as a Catalyst

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***Abstract*: In today's scenario, the population of vehicles is increasing day by day. These vehicles were running with the help of petrol or diesel engine. Due to abnormal combution in Spark Ignition and Compression Ignition engine, the NOx and CO are the two major pollutants from the exhaust. Numbers of technologies like improvement in engine design, fuel pre-treatment, use of alternative fuels, fuel additives, exhaust treatment or better tuning of the combustion processes are being considered to reduce the emission levels of the engines. This research work shows the characteristics of a new catalytic converter to be used for reduction of emissions. There are two types of catalytic converter based on the material and type of wire mesh used. Cerium oxide (CeO) and Cobalt oxide (CoO) is used as a catalyst for catalytic converter in the present work. To determine the emission contents from petrol and diesel Eco- Gas Analyzer 100 was used. The experiment was conducted for coated square type wire mesh catalytic converter.**

***Keywords*: emission control, catalytic converter, cerium oxide, cobalt oxide**

1. Introduction

The catalytic converter significantly reduces the amount of harmful gases. The hot gases with hydrocarbons (HC), Carbon Monoxide (CO), and oxides of Nitrogen (NOx) which are harmful to the environment sent through the exhaust valve. Exhaust gases are passed from the exhaust manifold to the catalytic converter. The catalytic converter the toxicity of these gases with the help of a catalysts Cerium Oxide (CeO) and Cobalt Oxide (CoO). There are basically two types of catalytic converter naming 2-way catalytic converter and 3-way catalytic converter. In 2-way catalytic converter only, Oxidation of gases will take place.

The best way to control the exhaust gas emission is the use of metal monolith. There are reasons behind usage of metal monolith instead of ceramic duct including availability of platinum group (Noble Metal), economy and the operating conditions of using platinum group based catalytic converter which emphasizes the investigation of Non Noble based catalyst material [2-4].

Nowadays, in automobile sector, catalysts like Platinum, Rhodium and Palladium are widely used. These catalysts are very high in costs. Due to this reason, the final cost of the catalytic converter also has become very high. In this research, work catalysts used are of Cobalt Oxide (CoO) and Cerium Oxide (CeO) i.e. these catalysts are low cost ones and absorb harmful pollutants. Authors have fabricated Catalytic Converter using the stainless steel wire mesh instead of honey comb ceramic duct [5].

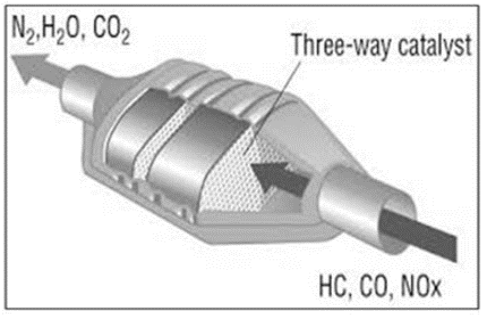

Fig. 1. Basic catalytic converter

Similar research work was done by M. A. Kalam et. al. [4]. Based on catalyst materials consisting of metal oxides such as Titanium Dioxide (TiO2) and cobalt oxide (CoO) with wire mesh substrate. The catalyst materials were inexpensive in comparison with conventional catalysts (noble metals) such as palladium, rhodium, platinum [6]. It is experimentally found that the conversion efficiencies of TiO_2/CoO based catalytic converter are 93%, 89% and 82% for NOx, CO and HC emissions respectively. In their results TiO_2/CoO based catalytic converter, reduced higher NOx, CO and HC emissions in comparison to earlier catalytic converters [7].

2. Experimental procedure

Wire mesh is fabricated as per the size of the catalytic converter. Stainless steel A 304 square type wire mesh is used as the substrate material in the fabrication of the catalytic converter [8].

A total of 50 pieces is taken in the circular shape of diameter 8.0 cm and are arranged in straight bars. The length of the stainless steel wire mesh is around 15.0cm. The gap between

each circular wire mesh piece is around 0.2 cm which is maintained by using the washer. Alumina and silica powder are used as the wash coating material for the coating of substrate to increase the irregular surface area of the wire mesh [9]. Cerium based catalytic converter is prepared with the 90g of Alumina silica powder and 10% Cerium oxide. Cerium oxide and cobalt oxide are used as a metal catalyst. It is mixed through the magnetic stir. The pure cobalt oxide (CoO) is used as the reducing agent and Cerium oxide (CeO) is using as oxidizing agent. Wire mesh is cleaned with the 10% of HCL solution for 30 minutes and then rinsed in distilled water before being dried in oven at temperature of 100°C. After preparing the slurry, the wire mesh pieces are dipped in the slurry by dipping technique. Finally prepared wire mesh pieces are then dried in oven at temperature of 120°C for 12 hours before Calcinations [10-12].

3. Materials required for current research work

Material required for the fabrication of the new Catalytic Converter is a Square type wire mesh, Distilled water, concentrated HCL Chemical catalyst i.e. Silica powder, Alumina powder, Cerium Oxide and Cobalt Oxide [13].

A. Designing of catalytic converter

Solid works is using for the designing of each component of catalytic converter.

B.P. - Boiling point, M.P- Melting Point, T.C- Thermal Conductivity

Table 1
Parameters of monoliths

Diameter in cm	Shape	Cell Shape	Wire Mesh
8.0	circular	Square	16

1) Casing

It is the outer part of the catalytic converter. The material which we are using is Mild steel, because of its good physical and thermal properties like high melting point, strength. The length of the casing was around 20cm [14]. As shown in Fig. 1.

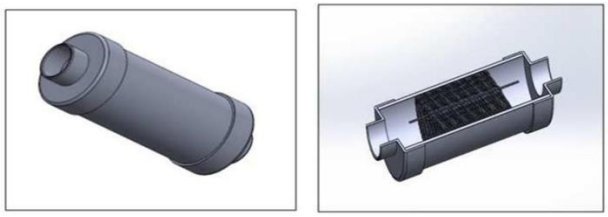

Fig. 1. Catalytic converter and cut section of catalytic Converter

2) Rod

In this experimental work, 50 pieces of wire mesh were arranged in a long straight bar. The length of arranged wire mesh was around 15 cm [15-18].

3) Washer

In fabricated catalytic converter, the gap between each of the wire mesh piece was around 0.2 cm which is produced by using the washer [15-18].

4) Wire mesh pieces

Wire mesh pieces used as substrate material in the catalytic converter. The material used for wire mesh is Stainless Steel because of the advantage of physical and thermal properties as well as low cost [19], [20]. The diameter of the circular piece was around 8.0cm of Square type as shown in Fig. 2.

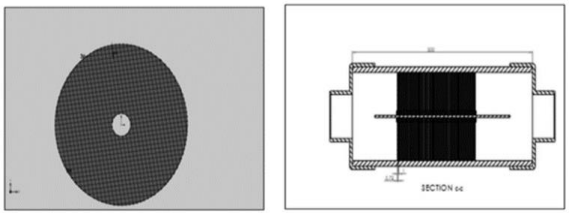

Fig. 2. Wire mesh piece and designed wire mesh arrangement

4. Preparing stirring mixture

It is prepared by mixing chemicals like alumina, silica solution in which Cerium oxide (CeO) and Cobalt Oxide (CoO) used as catalyst for increasing the rate of reaction to control the harmful pollutants namely CO, CO_2, HC and NOX. These catalysts are responsible for both oxidation and reduction reaction in exhaust gas emissions [21]. These chemicals react with the exhaust gases and convert toxic gases HC, CO, NOX into nontoxic H_2O, CO, N_2 and O_2. 90 grams of Alumina silica solution added to the 10 gram of CeO to get 10% Cerium Oxide (CeO) slurry. The slurry then stirred at 500 RPM for two hours at 600°C. Two grams of Cobalt Oxide (CoO) is gradually added in the slurry mixture [22].

5. Treatment of wire mesh substrate

The circular pieces of wire mesh were then immersed into a preparation of 10% HCL solution for 30 minutes to remove all the impurities. Then, these wire meshes were rinsed in distilled water before being dried in an oven at temperature of 1000C. The drying process takes about 1 hour before coating it with catalyst [23].

A. Substrate coating

The stainless steel wire mesh pieces, then coated with the metal catalyst via dipping technique. After powered process, coated stainless steel wire mesh was dried in oven at temperature of 120°c for 6 hours before being claimed in a muffle furnace [24].

Calcination is a process in which a material is heated to a high temperature and the volatile material is expelled. Calcination take 4 hours at a temperature of 550°c with temperature ramping up on 10.0°c/min and holding time of 300 minutes. After the calcination process, the stainless steel wire mesh arranged into a straight bar to become a substrate for use as a catalytic converter [25].

6. Fabrication of catalytic converter

The stainless steel square type wire mesh were cut into the circular pieces of the die 8cm as shown in Fig. 3.

Table 2
Catalytic converter dimensions

Specifications	Dimensions
Length of Casing	20cm
Diameter of Casing	8cm
Inlet diameter of Reducing Coupling	5cm
Outlet diameter of Reducing Coupling	8cm
Inlet diameter of Reducer	3cm
Outlet diameter of Reducer	5cm

Total 50 pieces coated with the catalyst were arranged on to a straight bar. The total length of the Stainless Steel 304 wire mesh arrangement was around 15.0 cm as shown in figure. The gap between each piece of stainless steel wire mesh was around 0.2 cm and was created by using the washer [4][21]. Finally the catalytic converter with catalyst coating has been successfully fabricated as shown in Fig. 3.

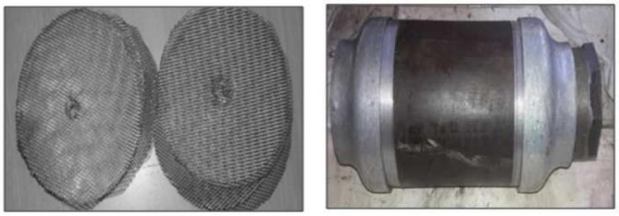

Fig. 3. Wire mesh pieces and fabricated CC

7. Experimental setup and procedure

A. *Engine setup for LPG engine*

A single twin spark plug, 4-stroke DTSi engine was used to collect the data. The rated power was 8.5 KW @6000 RPM. Detailed specification of the engine is given in the table 1. Smoke meter five- gas analyzer was used to measure the pollution content as shown in Fig. 4 [25].

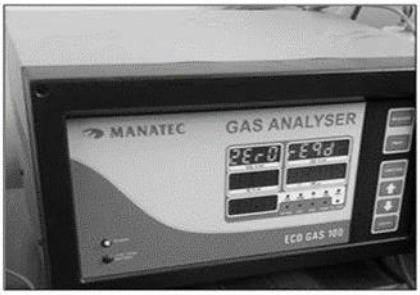

Fig. 4. Five gas analyzer

A probe was mounted at the end of the tail pipe, which supplies the sample of exhaust gas to the smoke meter as shown in Fig. 4.

Table 3
Engine Specification (LPG)

Type	Twin Spark Plug,4-Stroke DTSi
Maximum power	8.5 @ 6000 (Kw @ RPM)
Maximum Speed	65 km/hr
Maximum Torque	15.5@4250 (Nm @ RPM)
Displacement	198.88cc
Number of cylinders	One

B. *Engine setup for petrol engine*

A single-cylinder 4-stroke engine was used to collect the data. The rated power is 5.5 KW at 8000 RPM and the maximum torque is 7.95 N-m at 4500 RPM. Detailed specification of the engine is given in the table 2. Smoke meter five- gas analyzer was used to measure the pollution content. A probe was mounted at the end of the tail pipe which supplies the sample of exhaust gas to the smoke meter [4], [25].

Table 4
Engine specification (Petrol)

Type	Air Cooled, 4-Stroke single Cylinder
Maximum Power	5.5 @ 8000 (Kw @ RPM)
Maximum Speed	87 km/h
Maximum Torque	7.95@4500 (Nm @ RPM)
Displacement	97.2cc
Number of cylinders	One

8. Conclusion

From the experimental result, it has been concluded that the development of cobalt oxide and Cerium oxide based catalytic converter is feasible. Both the experiments on Petrol and LPG engine were conducted in such condition in which the readings were not affected by temperature, pressure, moisture, relative humidity. In the above conditions, engine was run at an ideal speed for 5 minutes to make sure that the engine comes into desirable condition which is required and favorable for the experiments. It is concluded that reduction of HC, CO, CO_2, NO_X to the greatest extent with the help of the catalytic converter.

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