

# **Emission Analysis in Multi-Cylinder SI Engine Using in Cylinder Treatment (Metal Oxide Coated Piston and Cylinder) and Post Treatment (Wire Mesh Catalytic Converter)**

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**ABSTRACT:** Petrol engines are widely used in transportation and Agricultural sectors. The exhaust of petrol engine contains hazardous pollutants such as Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NO<sub>x</sub>), Sulphur Oxides (SO<sub>x</sub>) and particulates. These emissions from engines cause a lot of health problems such as lung cancer, tuberculosis and other respiratory diseases to human beings, animals and . Further, burning of the fossil fuels creates a higher level of pollutant gases in the atmosphere, which increases the global warming. Therefore the emission from petrol engines has become a serious subject for research. Hence, Extensive research has been done in order to control the hazardous emission. In the present investigation, an attempt has been made to control the emissions combined effect of incylinder treatment (coating metal oxide over the piston top and inside the cylinder head) and metal oxides coated wire mesh as the catalytic converter. The coating is being done by using vacuum coating unit over the top of the piston and electroplating process for coating inside the cylinder head. The experiments conducted when catalysts coated piston and cylinder head and the coated meshes as the catalytic converter are fitted with the engine and in the exhaust line, the emissions from the engine have been controlled adopting this technique was found effective.

**KEYWORDS:** Multi-cylinder, SI Engine, Catalytic converter, Piston and cylinder head.

## **I. INTRODUCTION**

Petrol engines are prime movers for use in agricultural and transportation sectors. International emission regulations in recent years imposed more rigorous limits on engine emissions. Further, burning of fossil fuels creates a higher level of pollutant in the atmospheric air, which also increases the green house effect. Therefore the emission from petrol engines has become a serious subject for research. The pollutant emissions from petrol engines can be controlled by catalysts coated on the piston top and inside the cylinder head. In-cylinder treatment can be performed by coating metal oxides on the top of the piston using vacuum coating machine. As the coating area inside the cylinder head is larger, vacuum coating machine cannot be used for coating inside the cylinder head, the electroplating process is the alternative method used for coating large area for coating metal oxide on the wire mesh also the vacuum coating meshes is used.

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## II. EXPERIMENTAL SETUP

Five gas analyzers were used for the measurement of HC, CO, NO<sub>x</sub> and CO<sub>2</sub>. Experiments were initially carried out on the engine in order to provide base line data. The engine was stabilized before taking all measurements subsequently. The experiments were repeated when the oxide coated piston & cylinder head is fitted with the engine and wire mesh catalytic converter is kept in the exhaust line. A multi cylinder Four Stroke Petrol Engine was used. Engine details are given in Table-1.

**Table -1: Engine Specification**

Parameter	Details
Engine	Four-Stroke Multi cylinder SI Engine
Make	Premier Automobile Limited, India
Rated power	7.5 kW
Maximum speed	4500rpm
Bore diameter	68mm
Stroke	75mm
Displacement volume	1089cc
Compression ratio	7.3:1
Number of cylinders	Four
Cycle	Four
Cooling	Water
Lubrication	Forced Lubrication
Starting system	Battery Ignition System

The experimental set up is shown in Fig 1.

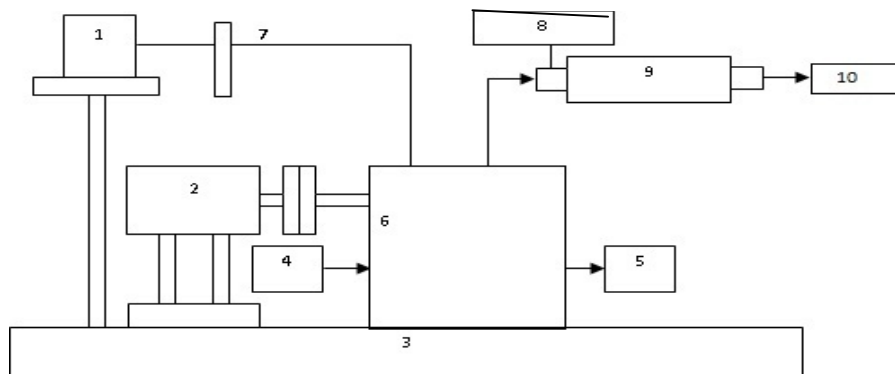


Fig 1: Layout of Test Engine

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Schematic diagram of the Test Engine with Catalytic Coated Filters are shown in Fig 2 and Fig 3.



Fig 2: Test Engine

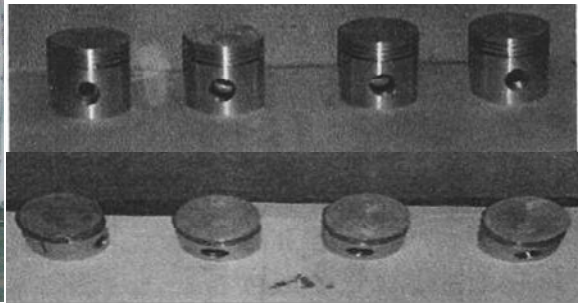


Fig 3: Pistons Before and After Coating

**Table -2 : Alternator Specification**

An electrical Dynamometer is used for loading the engine, the specification which is shown in table-2.

Table -2	
Parameter	Details
Loading device	Electrical
Rated power	7kW
Rater speed	1500rpm

### 3. Vacuum Coating Machine

HINDHIVAC Vacuum Coater-12A4D can perform a large number of industrial and laboratory applications like preparation of thui films for Optical and Electronic applications, preparation of specimens or Electron Microscope, etc. The basic unit consists of a cabinet containing a vacuum pumping system together with all the electrical components necessary for the coating process.



Figure 4: HINDHIVAC Vacuum Coater



Fig 5: Mesh Coating

### 3.1 Dimension of Pistons

Bore Diameter : 68 mm dia cylinder bore  
Cold Clearance : 0.020 mm  
Make : Premier Padmini-3RV

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### 3.2 Vacuum Chamber

The chamber is fabricated from electrochemically polished stainless steel. Three circular glass windows enable visual inspection of the coating process. When the chamber is placed on the base plate it makes a vacuum tight seal with the base plate by means of an 'L' type neoprene gasket.

### 3.3 Pumping System

The chamber is evacuated by a HINDHIVAC diff packs pump Model-1 14D and backed by 250 liters per minute, double stage, direct driven, rotary vacuum pump, Model ED-15 with an overload protection.

### 3.4 Exhaust Gas Analyzer

Measurement was done with the help of Automatic Emission Analyser QRO – 402. (Fig. 6)



Fig. 6 Automatic Exhaust Emission Analyzer

A cooling water pipe line is coiled on the outer wall of the chamber to prevent overheating, and to reduce the out gassing by circulating the water. Alternatively a glass bell jar is supplied along with the unit. The analyzer is configured to perform a measurement by applying non-dispersive infrared (NDIR) method for analyzing CO, HC and CO<sub>2</sub> and electro-chemical method for analyzing NO<sub>2</sub> and O<sub>2</sub>. In NDIR analyzing method, an infrared flashing lamp is attached at one end of the sample cell and a detecting sensor at the other end, so that it can detect the component of gas and in turn its density. The electrochemical method measures the gas density by using the quantity of electron which produced in the time of oxidation and reducing reaction of the gas.

### 3.5 Electroplating Process

CuO was coated on the cylinder head by electroplating plating process as it is relatively simple compared to PVD process. The cylinder head was chemically treated to remove rust, scale, grease and oil. The electrolyte was a mixture of CuCN, NaCN and Rochelle Cyanide with distilled water. When electric current was passed by keeping the cylinder head as cathode and Cu rod as anode, copper gets coated on the cylinder head. Then Copper hydroxide solution was poured on the basin of head which was kept in an electrically heated oven at 250°C. Subsequently, the cylinder head was dried in open atmosphere.

## IV. RESULTS AND DISCUSSION

The variations in emission of CO, CO<sub>2</sub>, HC and NO<sub>x</sub> were analyzed in the engine before and after In-cylinder & Post Treatment. The emissions were recorded using exhaust gas analyzer before and after the treatments and tabulated. The recorded data have been plotted and shown in Figure 7-10.

Figure 7 shows the variation of CO while the test was conducted by implementing the combination of both incylinder modification and post treatment. The trend obtained clearly reveals that there is drastic reduction in CO emission is obtained. The core reason behind this scenario is that while doing coating inside piston head as mentioned it enhances the combustion by retaining heat. The coated area acts as an insulator there by reduces heat loss and facilities for complete burning of fuel so most of CO is oxidized. Then by doing coating in the catalytic converter surface area with various oxides it helps for oxidation of CO thereby it further reduces CO to a greater value. Finally by adopting combination of these techniques the CO value is reduced to a greater amount.

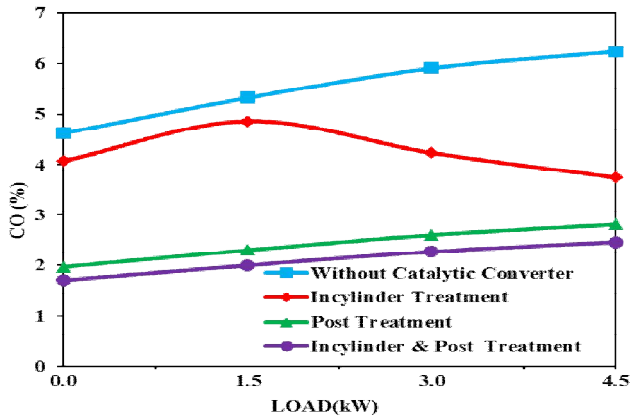


Figure 7

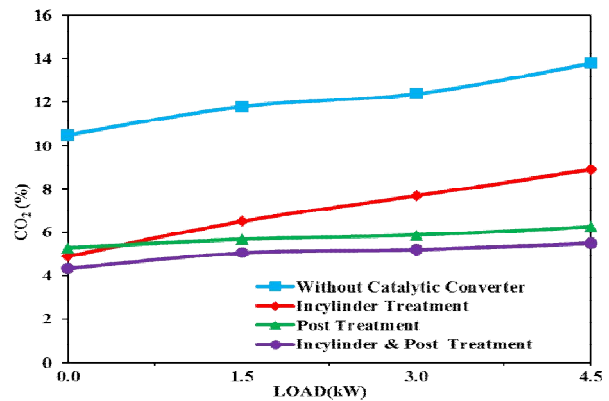


Figure 8

Figure 8 shows the variation of CO<sub>2</sub> while the test was conducted by implementing the combination of both incylinder modification and post treatment. The trend obtained clearly reveals that there is drastic reduction in CO<sub>2</sub> emission is obtained. The core reason behind this scenario is that while doing coating inside piston head as mentioned before it enhances the combustion by retaining heat. The coated area acts as an insulator there by reduces heat loss and facilities for complete burning of fuel so most of CO<sub>2</sub> is oxidized. Then by doing coating in the catalytic converter surface area with various oxides it helps for oxidation of CO<sub>2</sub> thereby it further reduces CO<sub>2</sub> to a greater value. Finally by adopting combination of these techniques the CO<sub>2</sub> value also has been reduced to a greater amount.

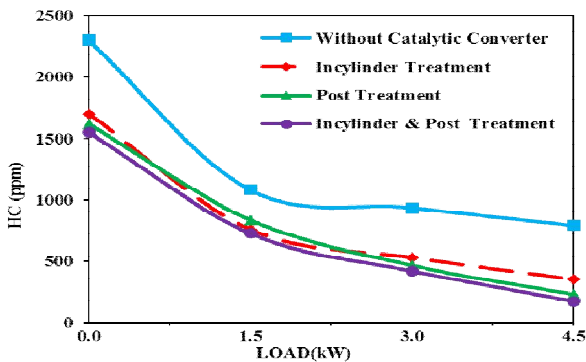


Figure 9

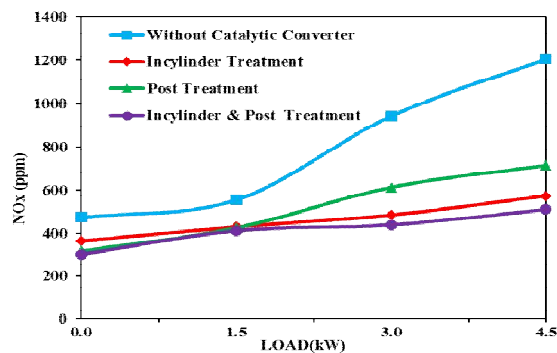


Figure 10

Figure 9 shows the variation of HC while the test was conducted by implementing the combination of both incylinder modification and post treatment. The trend obtained clearly reveals that there is drastic reduction in HC emission is obtained. The core reason behind this scenario is that while doing coating inside piston head as mentioned it enhances the combustion by retaining heat. The coated area acts as an insulator there by reduces heat loss and facilities for complete burning of fuel so most of HC is oxidized. Then by doing coating in the catalytic converter surface area with various oxides it helps for oxidation of HC thereby it further reduces HC to a greater value. Finally by adopting combination of these techniques the HC value is reduced to a greater amount.

Figure 10 shows the variation of NO<sub>x</sub> while the test was conducted by implementing the combination of both incylinder modification and post treatment. The trend obtained clearly reveals there is drastic reduction in NO<sub>x</sub> emission is obtained. The core reason behind this scenario is that while doing coating inside piston head as mentioned it enhances the combustion by retaining heat. The coated area acts as an insulator there by reduces heat loss and facilities for complete burning of fuel so most of NO<sub>x</sub> is converted into N<sub>2</sub>. Then by doing coating in the catalytic converter



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surface area with various metal oxides, it helps for reduction of  $\text{NO}_x$  thereby it further reduces  $\text{NO}_x$  to a greater value. Finally by adopting combination of these techniques the  $\text{NO}_x$  value is reduced to a greater amount.

As shown in the Figure 7-10, the emissions of  $\text{NO}_x$ ,  $\text{CO}_2$ , HC and CO were relatively low in the engine after In-cylinder & Post Treatment when compared to the emission from the engine before treatments. Moreover, the emission levels of pollutants were relatively decreased after In-cylinder & Post Treatment. Furthermore, the emissions of pollutants were effectively controlled at higher loads.

The rate of variation of pollutants percentage from the engine were calculated from the measured values and the variations were tabulated. In-cylinder & Post Treatments effectively controls the emission of CO,  $\text{CO}_2$ , HC and  $\text{NO}_x$  especially, when the engine runs at the load of 4.5 kW.

## V. CONCLUSIONS

Following are the conclusions based on experimental results.

- The use of combined In-cylinder treatment and Post treatment (Mesh treatment) reduces the emission of
  - $\text{NO}_x$  by 25 percent.
  - $\text{CO}_2$  by 20 percent.
  - CO by 15 percent.
  - HC by 80 percent.

From the conclusions it is found that the combined In-cylinder treatment and Post treatment (Mesh treatment) to control the emission from the engines, it may yield better results in reducing the  $\text{NO}_x$ ,  $\text{CO}_2$ , HC and CO.

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