

Emission Analysis in Multi-Cylinder SI Engine using In Cylinder Treatment (Metal Oxide Coated Piston and Cylinder) and Post Treatment (Pelletized Catalytic Converter)

K. Parthiban¹, K.Pazhanivel²

Assistant Professor, Department of Mechanical Engineering, Thanthai Periyar Govt. Institute of Technology, Vellore,
Tamil Nadu, India¹

Associate Professor, Department of Mechanical Engineering, Thiruvalluvar College of Engineering and Technology,
Vandavasi, Chennai, Tamil Nadu, India²

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_x), Sulphur Oxides (SO_x) 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 by combined effect of incylinder treatment (coating metal oxide over the piston top and inside the cylinder head) and metal oxides pellets 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 metal oxide pellets as the catalytic converter are fitted with the engine and the exhaust life, this technique was found effective in controlling the pollutants from the engine.

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. 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.

II. EXPERIMENTAL SETUP

Five gas analyzers were used for the measurement of HC, CO, NO_x and CO₂. 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 metal oxide

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pelletized 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.

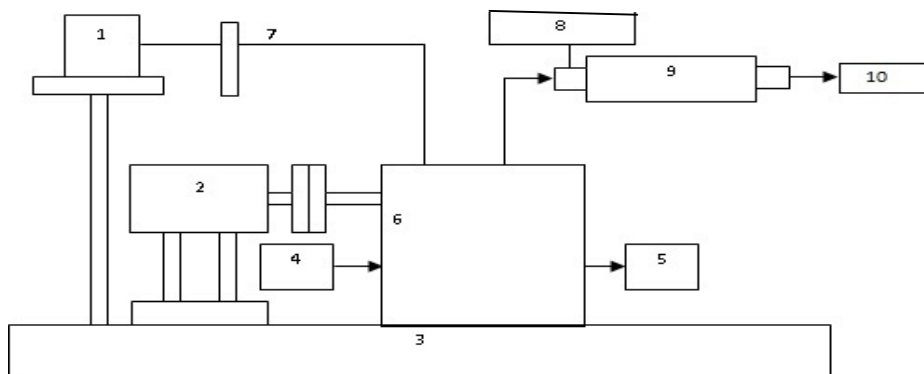


Fig 1: Layout of Test Engine

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

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Fig 2: Test Engine



Fig 3: Pellets 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

III. 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.



Fig 4: HINDHIVAC Vacuum Coater

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. 5)



Fig. 5 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 CO₂ and electro-chemical method for analyzing NO₂ and O₂. 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 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, CO₂, HC and NO_x were analyzed in the engine before and after In-cylinder and Pellet treatments. 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 6-9.

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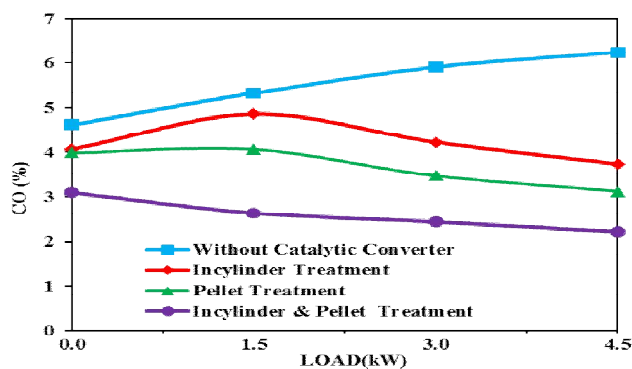


Figure 6

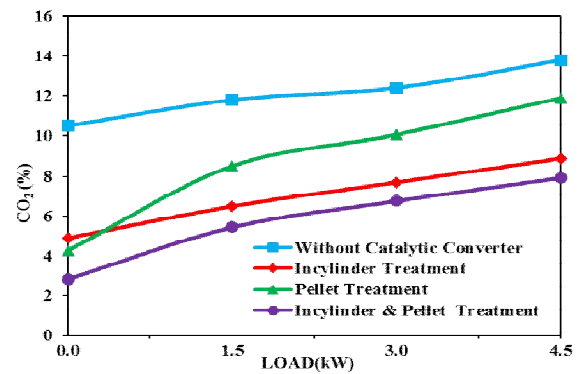


Figure 7

Figure 6 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 placing the metal oxides pellets as the catalytic converter 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 shows the variation of CO₂ 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 CO₂ 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 CO₂ is oxidized. Then placing the metal oxide pellets as the catalytic converter with various oxides it helps for oxidation of CO₂ thereby it further reduces CO₂ to a greater value. Finally by adopting combination of these techniques the CO₂ value is reduced to a greater amount.

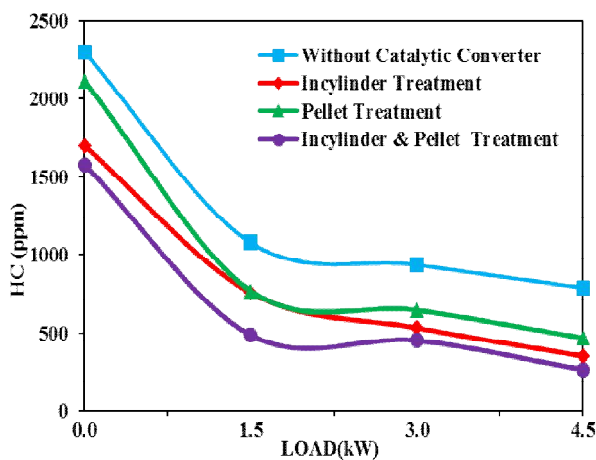


Figure 8

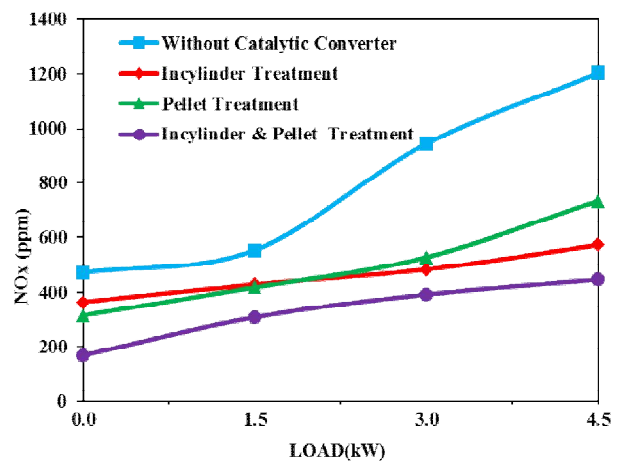


Figure 9

Figure 8 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

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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 placing the metal oxide pellets as the catalytic converter 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 9 shows the variation of NO_x while the test was conducted by implementing the combination of both in cylinder modification and post treatment. The trend obtained clearly reveals that there is drastic reduction in NO_x 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_x is converted into N₂. Then by placing the metal oxide pellets as the catalytic converter helps for Reduction of NO_x thereby it further reduces NO_x to a greater value. Finally by adopting combination of these techniques the NO_x value is reduced to a greater amount.

As shown in the Figure 6-9, the emissions of NO_x, CO₂, HC and CO were relatively low in the engine after In-cylinder & Pellets treatment when compared to the emission from the engine before treatments. Moreover, the emission level of pollutants was relatively decreased after In-cylinder & pellets treatment. Furthermore, the emission of pollutants was effectively controlled at higher loads. The rate of variation of pollutants percentage from the engine was calculated from the measured values and the variations have been discussed. In-cylinder & Pellet treatments effectively controls the emission of CO, HC and 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 Incylinder treatment and Post treatment (Pelletized treatment) reduces the emission of
 - NO_x by 51 percent.
 - CO₂ by 57 percent.
 - CO by 33 percent.
 - HC by 77 percent.

From the conclusions it is found that the combined Incylinder treatment and Post treatment (Pelletized treatment) to control the emission from the engines, it may yield better results in reducing the NO_x, CO₂, HC and CO.

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