

# Emission Control in Multi-Cylinder SI Engine Using Catalytic Coated Piston and Cylinder Head

K. Parthiban<sup>1</sup>, K.Jeyachandran<sup>2</sup>, K.Pazhanivel<sup>3</sup>

Senior Lecturer, Department of Mechanical Engineering, Thanthai Periyar Govt. Institute of Technology, Vellore,  
Tamil Nadu, India<sup>1</sup>

Director (Research) (Retd.), Anna University, Chennai, Tamil Nadu, India<sup>2</sup>

Associate Professor, Department of Mechanical Engineering, Thiruvalluvar College of Engineering and Technology,  
Vandavasi, Chennai, Tamil Nadu, India<sup>3</sup>

**ABSTRACT:** The internal combustion engines generate undesirable emissions during the combustion process. The emissions exhausted into the surroundings pollute the atmosphere and harmful to human beings, animals and vegetation etc., The emissions are CO, HC, NO<sub>x</sub>, CO<sub>2</sub> etc. In the present investigation, an attempt has been made to control the emissions by coating metal oxide over the piston top and inside the cylinder head. 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 is fitted with the engine, 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 in 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.

## 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. 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.

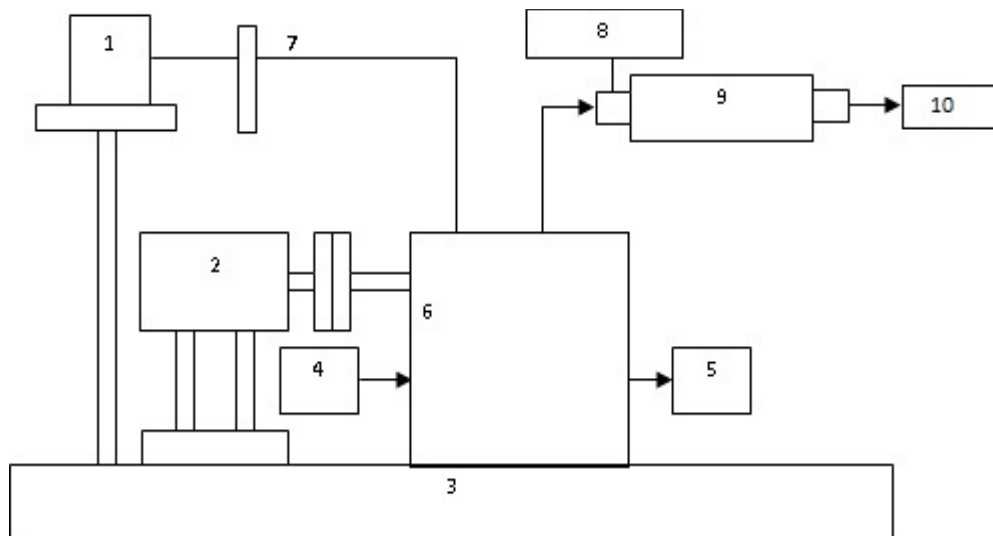


Fig 1: Layout of Test Engine

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



Fig 2: Test Engine

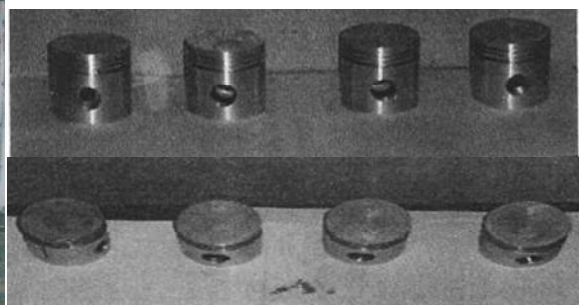


Fig 3: Pistons Before and After Coating

**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

### III. VACUUM COATING MACHINE

HINDHIVAC Vacuum Coater-12A4D can perform a large number of industrial and laboratory applications like preparation of thin films for Optical and Electronic applications, preparation of specimens for 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

#### 3.1 Dimension of Pistons

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

#### 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 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 250oC. Subsequently, the cylinder head was dried in open atmosphere.

**IV. RESULTS AND DISCUSSION**

**4.1 Emission performance when combination of metal oxide coated piston and cylinder head is fitted with the engine**

The emission performance of the engine with MgO coated piston and CuO coated cylinder head was analysed as a function of load. From the results, it has been observed that the combination of MgO coated piston and CuO coated cylinder head effectively reduced the emission of all pollutants. Figures 6-9 shows the variation of emission of CO, CO<sub>2</sub>, HC and NO<sub>x</sub> respectively with and without coating of MgO (on piston) and CuO (inside cylinder head).

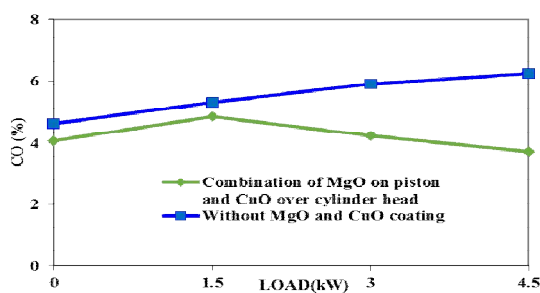


Figure 6: Load Vs CO

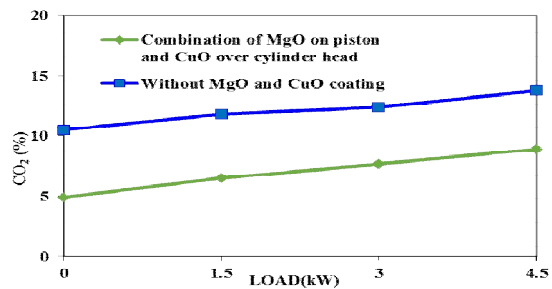


Figure 7: Load Vs CO<sub>2</sub>

As shown in Figure 6, the CO emissions for the base engine have increased with load and it reached a maximum value of 6% with for maximum load conditions. It has been observed that the implementation of a MgO coating on piston and CuO coating inside the cylinder head facilitated complete combustion which lead to decrease in the overall CO emission percentage in the exhaust. The conversion percentage is almost 25% in minimum load condition and progressively becomes close to 20% in the maximum load condition.

It has been observed from the Figure 7 that the CO<sub>2</sub> concentration has increased with increase in load for the base engine. This can be due to the presence of rich air fuel mixture with increased loads. The implementation of a MgO coating on piston and CuO coated inside cylinder head has facilitated to a reduced overall CO<sub>2</sub> percentage in the exhaust. The conversion percentage is almost 53% in minimum load condition and progressively becomes close to 35% in the maximum load conditions. Thus result ensured that the combined incylinder treatment has influenced to a greater extent to reduce the CO<sub>2</sub> emission from lower load to higher load.

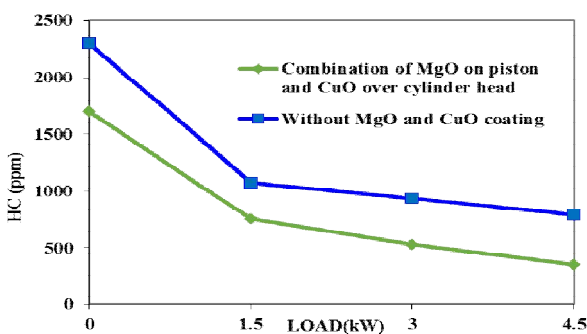


Figure 8: Load Vs HC

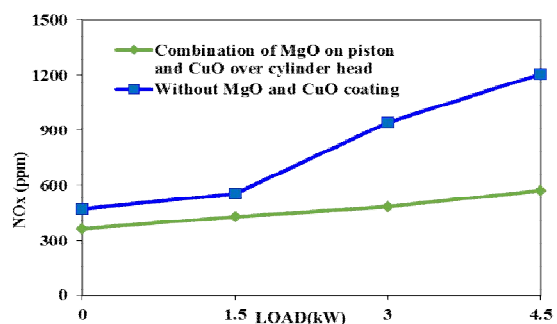


Figure 9: Load VsNO<sub>x</sub>

The HC concentration decreased with increase in load for the base engine as shown in Figure 8. This can be due to complete combustion occurred at higher load. It has been observed that the implementation of a MgO coated on piston and CuO coated cylinder head has facilitated complete combustion leading to a reduced HC percentage in the exhaust. The conversion percentage is almost 26% in minimum load condition and progressively reached to 55% in the maximum load condition.

The NO<sub>x</sub> concentration has increased with a rise in load for the base engine as shown in Figure 9. This is due to complete combustion occurred at increased loads and the presence of excess oxygen leading to complete combustion of charge to occurring at higher temperature. The implementation of a MgO coated piston and CuO coated cylinder head has increased NO<sub>x</sub> percentage in the exhaust. The conversion percentage is almost 23% in minimum load condition and progressively becomes close to 52% in the maximum load condition.

The percentage of reduction of pollutant was calculated from the measured values. Variation of the emission in the MgO (on piston) and CuO (inside the cylinder head) coated engine is evaluated. Results obtained from the experiments show that the combination of MgO (on piston) and CuO (on cylinder head) coating effectively controls the emission of CO<sub>2</sub>, HC and NO<sub>x</sub> when the engine runs at the load of 4.5 kW. Moreover, the combination of coated on piston (MgO) and cylinder head (CuO) effectively control all the pollutant emission compared to individual catalytic converter coating of either CuO or MgO due to the synergistic effect of both catalytic converter.

## V. CONCLUSIONS

Following are the conclusions based on experimental results.

- The use of coating Magnesium Oxide over the pistons and Copper oxide inside the cylinder head reduces the emission of
  - NO<sub>x</sub> by 52 percent.
  - CO<sub>2</sub> by 35 percent.
  - CO by 20 percent.
  - HC by 55 percent.

From the conclusions it is found that the Magnesium Oxide and Copper oxide were best catalyst to control the emission from the engines. When this catalyst coating over the piston is used, it may yield better results in reducing the NO<sub>x</sub>, HC and CO.

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