Emission Analysis in Multi-Cylinder SI Engine using In Cylinder Treatment (Metal Oxide Coated Piston and Cylinder) and Post Treatment (Pelletized 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 (NOₓ), Sulphur Oxides (SOₓ) 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, NOₓ 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
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**

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

The experimental set up is shown in Fig 1.

Schematic diagram of the Test Engine with Catalytic Coated Filters are shown in Fig 2 and Fig 3.
An electrical Dynamometer is used for loading the engine, the specification which is shown in table-2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading device</td>
<td>Electrical</td>
</tr>
<tr>
<td>Rated power</td>
<td>7kW</td>
</tr>
<tr>
<td>Rated speed</td>
<td>1500rpm</td>
</tr>
</tbody>
</table>

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.

3.1 Dimension of Pistons

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore Diameter</td>
<td>68 mm dia cylinder bore</td>
</tr>
<tr>
<td>Cold Clearance</td>
<td>0.020 mm</td>
</tr>
<tr>
<td>Make</td>
<td>Premier Padmini-3RV</td>
</tr>
</tbody>
</table>
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)

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 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

The variations in emission of CO, CO2, HC and NOx 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.
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 CO\textsubscript{2} 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\textsubscript{2} 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\textsubscript{2} is oxidized. Then placing the metal oxide pellets as the catalytic converter with various oxides it helps for oxidation of CO\textsubscript{2} thereby it further reduces CO\textsubscript{2} to a greater value. Finally by adopting combination of these techniques the CO\textsubscript{2} value is reduced to a greater amount.

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
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 NOx 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 NOx 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 NOx is converted into N2. Then by placing the metal oxide pellets as the catalytic converter helps for Reduction of NOx thereby it further reduces NOx to a greater value. Finally by adopting combination of these techniques the NOx value is reduced to a greater amount.

As shown in the Figure 6-9, the emissions of NO\textsubscript{x}, CO\textsubscript{2}, 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\textsubscript{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\textsubscript{x} by 51 percent.
  - CO\textsubscript{2} 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\textsubscript{x}, CO\textsubscript{2}, HC and CO.

REFERENCES

[7] "National Ambient Air Quality Standards" Central Pollution Control Board(CPCB), 11 April 1994