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Emission control in multi-cylinder SI Engine using catalytic coated cylinder head

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Abstract - *Internal combustion engines generate undesirable emissions during the combustion process. The emissions exhausted into the surroundings pollute the atmosphere and harmful to human beings. The emissions are CO, HC, NO_X, CO_2 etc… In the present investigation, an attempt has been made to control the engine exhaust emissions by coating metal oxide inside the cylinder head. The coating is being done by using electroplating process inside the cylinder head. The results obtained from the experiments using metal oxide coated inside the cylinder head were analyzed. [4] The emission control achieved by adopting this technique was found effective.*

Key Words: Multi-cylinder, SI Engine, Catalytic converter, Cylinder head.

1. INTRODUCTION

Success of any modern technology is decided by the utilization of society harmless to human beings. In the automobile industry, Engines are the backbone classified into two major categories viz. 1.Internal combustion engine and 2.External combustion engine. In Internal Combustion (IC) Engines, combustion takes place inside the engine, whereas in External Combustion (EC) Engines combustion takes place outside the engine. Among the various types of engines, the most used engines are reciprocating IC engines. Higher thermal efficiency can be obtained with moderate working pressure of the fluid therefore the weight to power ratio is less in IC engines. In-cylinder treatment can be performed by coating metal oxides 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. Thermal analysis of holes created on ceramic coating for petrol engine piston was studied concerning with the steady state thermal analysis of petrol engine piston coated with ceramic coating having holes on its surface.

2. EXPERIMENTAL SETUP

Five gas analyzers were used for the measurement of HC, CO, NO_X and CO_2. 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 by keeping different catalyst coated filter in the exhaust. 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 layout is shown in Fig 1.

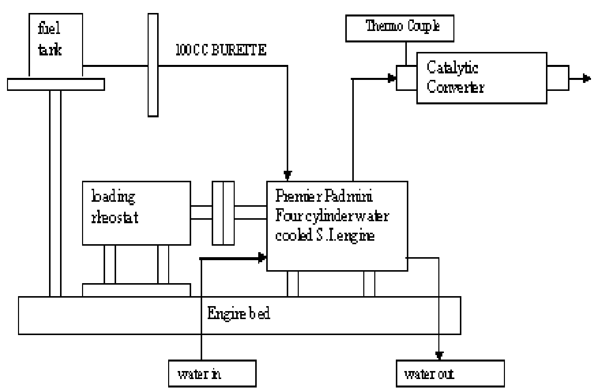

Fig 1: Layout of Test Engine

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

Table -2: Alternator Specification

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

Schematic diagram of the Test Engine are shown in Fig 2.

Fig 2: Test Engine

The present experimental setup for testing the performance of emission of engine shown schematically in figure 2, which consist of multi-cylinder water cooled petrol engine coupled to alternator with water rheostat. The fuel level in the fuel tank, flow of cooling water and level of lubricating oil sump is checked before starting the engine. The engine is started by turning the ignition key and the clutch lever is disengaged to couple the engine and adjusted to the speed of 1440 rpm. The engine is allowed to run for 10 minutes to attain steady state condition. At no load condition, CO, CO_2, HC & NOx are measured by using exhaust gas analyzer. The load on the engine is increased by dipping the electrode in the water of the rheostat after reaching the steady state conditions all the above readings are taken for each increment of the load. The load is completely removed and the speed is reduced before stopping the engine. Then the fuel has been modified by adding Ethanol in various proportions and the emission analysis has been carried out.

3. 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.

3.1 Exhaust emission analyser

Measurement was done with the help of Automatic Emission Analyser QRO – 402. (Fig. 3)

Fig. 3 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_2 and electro-chemical method for analyzing NO_2 and O_2. 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.

4. Results and Discussion

4.1 Effect of emission when the catalytic coated cylinder head fitted with the engine

The emission of CO, CO_2, HC and NO_x from the engine before and after coating CuO inner side the cylinder head was analyzed using exhaust gas analyzer. The variation of CO, CO_2, HC and NO_x emission before and after CuO coating is shown as a function of load in Figures 4- respectively.

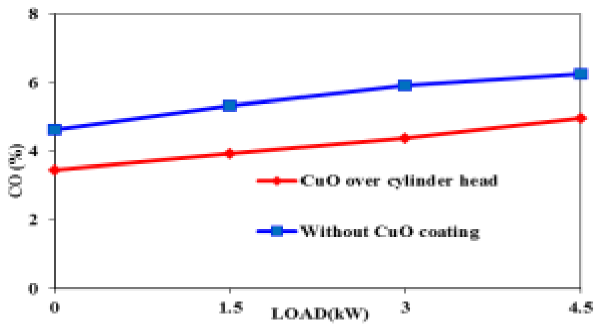

Fig 4: Load Vs CO

It is observed from Figure 3 that the CO emissions from the base engine has increased with load and it has reached a maximum value of 6% for maximum load condition. It is clearly understood that the implementation of a copper oxide coated cylinder head has facilitated complete combustion leading to a decrease in the overall CO percentage in the exhaust. The conversion percentage is almost 25% in minimum load condition and becomes close to 20% in the maximum load condition. The decreased percentage of conversion at higher load is due to the relatively less clean combustion.

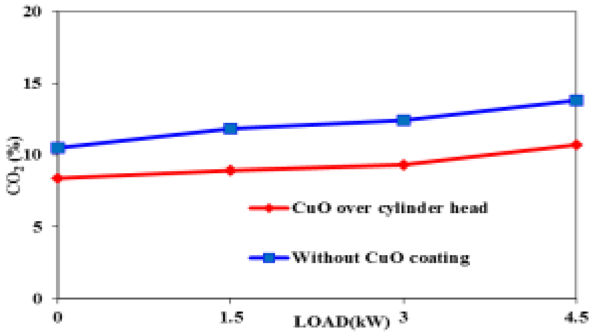

Fig 5: Load Vs CO_2

From Figure 5 it has been observed that the CO_2 concentration has increased with load for the base engine. This can be due to the presence of rich air fuel mixture at increased loads. The implementation of a Copper oxide coated cylinder head has facilitated complete combustion leading to a reduced overall CO_2 percentage in the exhaust which is due to clean burning of fuel as the combustion temperature raised inside. The conversion percentage is almost 37% in minimum load condition and progressively becomes close to 20% in the maximum load condition which is due to relatively less clean combustion. Comparing the significance of MgO coating on piston top and CuO on inside the cylinder head it is seen that MgO deposition is more effective.

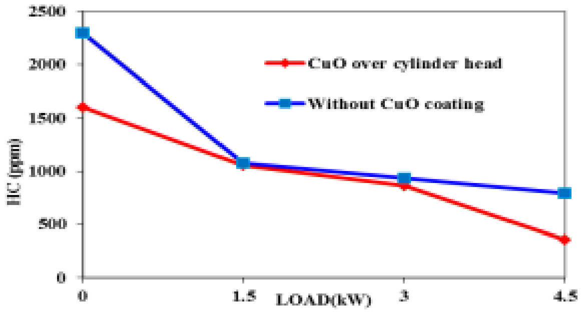

Fig 6: Load Vs HC

It has been observed from the Figure 6 that the HC concentration has decreased with increase in load for the base engine. This can be due to complete combustion occurring due to the increase of temperature when the load is increased. The implementation of a copper oxide coated cylinder head has facilitated complete combustion leading to a reduced HC percentage in the exhaust. The conversion percentage is almost 30% in minimum load condition and progressively becomes close to 54% in the maximum load condition, as the increase in temperature facilitated the clean combustion. Comparing the significance of MgO coating on piston top and CuO on cylinder head, it is seen that MgO deposition is more effective.

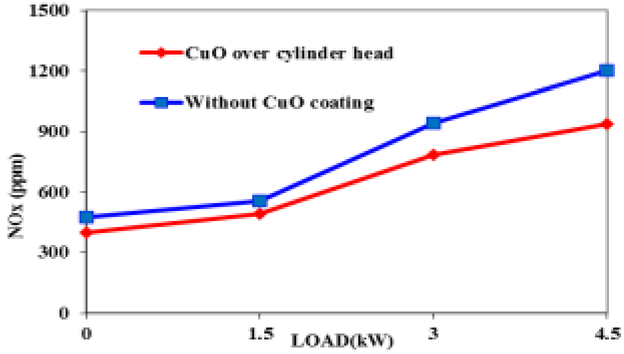

Fig 7: Load Vs NOx

From the Figure 4.3d, it has been observed that the NO_x concentration has increased with increase of load for the base engine. This is due to incomplete combustion occurred at higher loads and the presence of unburnt excess oxygen leads to formation of various oxide of nitrogen. The implementation of a copper oxide coated cylinder head has facilitated, increased temperature and hence enhanced the complete combustion lead to the increased NO_x percentage in the exhaust at higher load. The conversion percentage is almost 16% in minimum load condition and progressively becomes close to 22% in the maximum load condition.
Results obtained from the experiments illustrate that the CuO coating inside the cylinder head effectively controls the emission of HC compared to other pollutant at the load of 4.5 kW.

5. CONCLUSIONS

Following are the conclusions based on experimental results.

- The use of coating Copper Oxide over the pistons reduces the emission of
  - NO_x by 22 percent.
  - CO_2 by 20 percent.
  - CO by 20 percent.
  - HC by 54 percent.

From the conclusions it is found that the Copper Oxide was 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_x, HC and CO.

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