

Emission Analysis of Copper Coating in Piston Crown and Cylinder Head Engine

M.Dharanaikumar¹ · R.Chandraboopathi² · S.Ragu³ · K.Vijayaraghavan⁴

Lecturer, Department of Mechanical Engineering, Karpagam college of Engineering, Coimbatore, India ^{1,2, 3&4}.

ABSTRACT: The major pollutants emitted from Spark Ignition engine are carbon monoxide (CO) and unburnt hydrocarbons (UHC). These are hazardous and cause health problems to human beings, and hence control of these pollutants calls for immediate attention. It has been identified from the literature review that copper coating inside the cylinder head and over the piston crown will reduce the emission and increase the overall performance. Hence, in this Project work piston is coated using copper and experiment will be conducted. The Bajaj 150cc vehicle load is used for conducting experiment. The copper coated engine is used to improve the engine, Fuel consumption and emission (HC, CO, O₂, and CO₂). The performance characteristics of the copper coated engine will also be studied.

KEYWORDS: emission control, un-burnt hydrocarbon, copper coating.

I. INTRODUCTION

The engine manufacturer as well as automobile industry is facing a serious challenge to improve engine efficiency. Governments are legislating stricter fuel consumption regulations and consumers are purchasing more fuel efficient models to reduce their environmental impact and spending on dearer fuel. The major pollutants emitted from spark ignition engine are carbon monoxide (CO) and unburnt hydrocarbons (UHC). These are hazardous and cause health problems to human beings, and hence control of these pollutants calls for immediate attention. Copper, which has thickness of 300 microns, is coated over piston crown and inside portion of the cylinder head of the spark ignition engine.

A microprocessor-based analyzer is used for the measurement of CO/UHC in the exhaust of the engine. Copper coated spark ignition engine with gasoline operation reduced the exhaust emissions considerably when compared to conventional engine with pure gasoline operation. The engine manufacturer as well as automobile industry is facing a serious challenge to improve engine efficiency. Governments are legislating stricter fuel consumption regulations and consumers are purchasing more fuel efficient models to reduce their environmental impact and spending on dearer fuel.

II. LITERATURE SURVEY

[1] Performance evaluation of four stroke single cylinder spark ignition engine with methanol blended gasoline having copper coated engine (copper thickness 300.25) coated on piston crown and inner side of cylinder head and compared with conventional SI engine with the operation of Gasoline. There is an increase in brake thermal efficiency with methanol blended gasoline with both engine types. Copper coated engine showed improvement in performance than conventional engine with both test fuel samples. Catalytic converter with air injection significantly reduced pollutants with both test fuels on both engine types.

Adulteration of automotive fuels, particularly gasoline with cheaper fuels is widely spread out through south Asia. Some of the adulterants decrease the performance and life of the engine. At the same time, it increases the emission of harmful pollutants causing environmental and health problems. This present investigation is carried out to study the exhaust emissions from a single cylinder spark ignition engine (SI) engine with kerosene blended gasoline with different versions of the engine, such as catalytic coated engine and conventional engine with different proportions of the kerosene ranging from 0% to 40% by volume in steps of 10% in the kerosene gasoline blend. The catalytic coated engine is used in the study has copper coating thickness 400microns on piston and inner surface of the cylinder head. Copper coated engine with catalytic converter significantly reduced pollutants when compared to conventional engine. These pollutants decreased by 20% with catalytic coated engine when compared to conventional engine with kerosene blended gasoline operation.

[2] Comparative analysis of heat release in baseline and insulated (piston crown with plasma sprayed zirconium coatings) diesel engine. Materials (used for engine combustion coatings) can be classified as conductors or insulators according to their thermal (electrical) conductivity. Two types of bonding mechanism occur in ceramic materials. Many ceramics (alumina, zirconia) contain both ionic and covalent bonding. In an insulator, electrons completely fill the

valence band (the highest energy band occupied by electrons) and the energy gap between valence band and the next band is large. This means that there is large gap between valence band and conduction band. When light strikes a ceramics it may be transmitted absorbed or reflected. Plasma spray zirconium coatings are effective as heat barrier during compression and premixed burning period. (i.e.) during this part of engine operating cycle when convective heat transfer is dominant. Low heat rejection during compression causes an advance in heat release beginning during diffusion combustion phase growing soot concentration in flame promotes radiation heat transfer.

[3] Ceramic coatings provide good thermal barrier properties for designers. When designing the adiabatic engines, reduction in-cylinder heat rejection requires very special thermal barrier coatings on the engine combustion chamber. Partially, Thermal Barrier Coating (TBC) on the top surface of the piston in the annulus form is considered as a solution for unburned HC emission produced by incomplete combustion with respect to crevice volume after SI engines start (the three-way catalytic converter is not yet activated in the period of first 120 s). As TBC on the top of the piston surface decreases the thermal conductivity and increases the unburned charge oxidation by increasing the temperature in the flame quenching area near the entrance of the crevice volume between the piston and liner during the compression and the early part of the expansion strokes.

In this study, a steady-state thermal analysis was performed to evaluate the temperature gradients in the standard and two different partially stabilized ceramic coated pistons by using Abacus finite element (FE) software. An increase in the temperature of the coated area of the piston was observed as a result of FE simulations. Ceramic coatings are widely used in industry for providing valuable improvements against wear, corrosion, erosion, and heat in designs.

In the spark-ignition engine, in order to minimize the main source of HC emissions in the crevice volume consisting of piston liner and top ring, partially ceramic coating was applied on the piston top surface near to crevice volume. Since full coating on piston top surface may lead to auto-ignition, the application was made only on the piston top surface area, having 10 mm length and 0.5 mm thickness, beginning from the outer diameter of the piston.

[4] His work investigates partial HCCI (homogeneous charge compression ignition) combustion as a control mechanism for HCCI combustion. The premixed fuel is supplied through a port fuel injection system located in the intake port of DI diesel engine. Cooled EGR is introduced for suppressing the advanced auto ignition of the premixed fuel. The premixed fuel samples used in this experiment are diesel, gasoline, and n- heptane. The result shows that diesel with premixed fuel has a simultaneous decrease of NO_x and soot can be obtained by increasing the premixed ratio.

However, when the inlet charge is heated for the improved vaporization of the diesel fuel resulted that high inlet temperature limits the operational range of HCCI combustion due to severe knocking and high NO_x emission at high premixed ratios. In addition, carbon dioxide (CO_2), one of major combustion products from existing internal combustion engines.

The only way to reduce CO_2 emitted from automotive engines is to improve the combustion efficiency of engine. Conventional SI engines use a spark to ignite the reactive mixture, whereas CI engines use injection of fuel to initiate mixing and subsequent combustion.

Under most operational conditions of diesel premixing, NO_x emissions decrease with increases in the premixed ratio. However, at higher premixed ratios and inlet temperatures, NO_x concentrations become greater than the value of conventional diesel engine and the increases of NO_x in this operational region can be explained by the advanced combustion prior to TDC.

[5] Approach is proposed and investigated to reduce unburned hydrocarbon emissions from a homogeneous charge compression ignition (HCCI) engine by using the in-cylinder catalysts. The emission and combustion characteristics of this HCCI engine are numerically simulated in 3cases, i.e., the baseline engine with an uncoated piston crown, the engine coated with a platinum on the top and side surfaces of the piston crown (full coated case) and the engine with a platinum coating only on the side surface of the piston crown (partial coated case). The results show that the unburned hydrocarbons of the HCCI engine arise primarily from sources near the combustion chamber wall, such as flame quenching at the entrance of crevice volumes, at the combustion chamber wall, the adsorption and desorption of methane in to and fro of the cylinder wall. The in-cylinder catalyst gives rise to a reduction of exhaust unburned hydrocarbon (UHC) emissions by approximately 15% with the full coating of platinum catalyst on the piston crown, however, partial coating of the in-cylinder catalyst can reduces the UHC emission by approximately 20%.

Unburned HC emissions are persistently reduced by about 15% with the platinum catalyst full coated on the piston crown. While in the case of the partial coating configuration, unburned HC emissions are reduced even by about 20%. The exhaust CO emissions are reduced by 13%, but the exhaust NO_x emissions are increased by 10% as a result of the

full coating of platinum catalyst on the piston crown. In the case of the partial coating configuration, the exhaust CO emissions are reduced by 7%, while the exhaust NO_x emissions do not change appreciably.

Objective

The main objectives of the work are mentioned below

- To minimize the emission of HC, CO, CO₂ and O₂ by using catalytic coating.
- To improve fuel efficiency in single cylinder 4 strokes petrol engine by using copper coating inside the combustion chamber.

Experimental Setup

The experimental setups were carried out on single cylinder four stroke petrol engine (Bajaj 150cc). The Exhaust emission such as (HC, CO, CO₂& O₂) was measured by using Automotive Emission Gas analyzer. The specification of the engine used for conducting the experiments is tabulated in table 1.

Table 1 Engine specifications

Engine Make	Bajaj 150 CC
Cylinder Bore	57.5 mm
Stroke	58 mm
Displacement	150 cc
Power	4.5 kW @5500 rpm
Con Rod Length	110 mm
Compression Ratio	7.4:1
Carburetor	Jetex, Down draft
Lubrication	Petrol

The main pollutants which are objectionable and are to be reduced are HC, CO, CO₂ and NO_x by using catalytic coating as one of the techniques widely used to reduce emission and improve performance [1].

Copper

Copper and gold are the earliest metals known to man and have been in use for about 10,000 years. The attractive properties which made copper so useful then - good corrosion resistance, attractive color, excellent workability and good mechanical properties - are relevant today and, in addition, copper has the best electrical and thermal conductivity of any commercial metal.

Properties

Copper is an excellent electrical Conductor. Most of its uses are based on this property or the fact that it is also a good thermal conductor. However, many of its applications also rely on one or more of its other properties.

The below mentioned are the physical properties of Copper material,

- Good electrical conductor
- Good thermal conductor
- Corrosion resistant
- Ductile
- Catalytic

Mechanical Properties

- Melting point - 1083°C
- Boiling - 2595°C
- Density - 8933kgm⁻³
- Tensile strength - 200 to 250 N/m²
- Thermal conductivity - 401 W/mk
- Thermal coefficient - 17.0X10⁻⁶m/k

Out of the different types of coating process available we have selected plasma spray coating process. The steps involved are

- Masking: Masking is one of the important processes which are the use of materials to protect areas from change to focus change another areas.

- **Blasting:** Blasting process is important in plasma Spray process. The blasting time of 3 to 65 seconds. The grit blasting in preparation for plasma spray depends on dry abrasives. The grit blast material should be sharp and angular so that it will cut into the substrate on input.
- **Bond coating:** The bonding mechanism at plasma Coating substrate interface and between the plastic makings up the plasma spray coating is in area. If generally suffices to state that both mechanical interlocking and diffusion bonding occur.
- **Copper powder coating:** Major process of plasma spray coating process. The dry copper powder is poured into the stock by spraying process can get copper powder substrate.
- **Cleaning & mask removing:** After complete the Plasma spray process allow some time to dry condition after that remove clean the parts. the below Figure 1 show piston head before coating the below Figure 2 show piston head after coating the below Figure 3 Coated Piston Crown and Cylinder Head Bottom used for the experimental set up.



Figure 1 Before Copper Coating



Figure 2 After Copper Coating



Figure 3 Coating on Piston Crown and Cylinder Head Bottom

Specifications of Copper Coating

- Coating thickness is 0.3mm
- Coating area is 6636.62mm²
- Coating process is plasma spray gun machine
- Coating powder is copper
- Powder size 25 micron above

Result and Discussion

The experimental were conducted on Single cylinder four stroke petrol engine and copper coated engine with varying wheel speed and the results are tabulated in the table. Emission of HC, CO₂, O₂ and CO was also noted. Standard engine and copper coated engine emissions readings are tabulated in table 2.

Table 2 Emission readings for Standard and Copper coated Engine at idle speed

GASES	BEFORE COATING	AFTER COATING
CO (% of Volume)	1.92	1.02
CO ₂ (% of Volume)	1.82	1.42
O ₂ (% of Volume)	17.42	15.37
HC (in PPM)	654	582

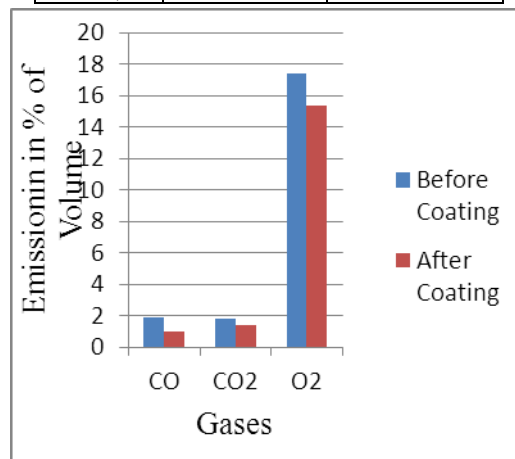


Figure 4 CO, CO₂, O₂ analysis of standard vs copper coated engine

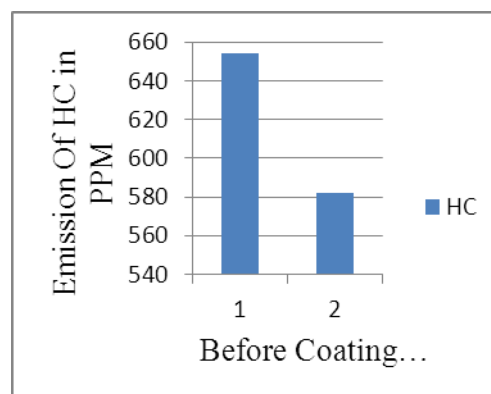


Figure 5 HC analysis of standard vs copper coated engine

From the experimental investigation of copper coated engine the following conclusion could be arrived.

- From the experimental results at idle speed the HC emissions is for standard engine is 654ppm, whereas HC emission is for copper coated engine is 582ppm. (i.e.) 11% emission is reduced for copper coated engine compared to standard engine. It is represented in graph.
- From Figure 4 CO emission standard engine is 1.92 % of volume where as copper coated engine gives 1.02% of volume. From the results is 46.7 % of emission is reduced in copper coated engine at idle speed condition.
- From the Figure 4 CO₂ emission standard engine is 1.82 % of volume where as copper coated engine gives 1.42% of volume. From the results is 21.9 % of emission is reduced in copper coated engine at idle speed condition

- From the Figure 4 O₂ emission standard engine is 17.42 % of volume where as copper coated engine gives 15.37% of volume. From the results is 11.7 % of emission is reduced in copper coated engine at idle speed condition
- Form Figure 5 emission of HC in PPM has reduced for 650 to 580.

III. CONCLUSION

Thus the emission of the exhaust gases namely HC, CO, CO₂ and O₂ have been reduced to 582 ppm, 1.02 %, 1.42 % and 15.37% respectively using Automotive Emission Gas Analyzer. This can be further reduced by implementing further additional technologies.

REFERENCES

- [1]M.V.S.Murali Krishna, K.Kishor, Journal of Scientific and Industrial Research, 2007, Vol.67, pp543-548.
- [2]Krzysztof Z.Mendera, Journal of KONES ,Internal combustion engines, 2000, Vol. 7, pp 112-121.
- [3] MesutDurat , Murat Kapsiz , Ergun Nart , FeritFicici , Adnan Parlak, Materials and design, 2012, Vol. 36,pp 540-545.
- [4]DaeSik Kim, Chang Silk Lee, fuel, 2006, Vol. 85, pp 695-704.
- [5]Wen Zeng, Mao ZhaoXie, Chemical Engineering journal, 2008, Vol.139, pp 380-389.
- [6]C Krishnaraj, KM Mohanasundaram, SR Devadasan, NM Sivaram, "Total failure mode and effect analysis: a powerful technique for overcoming failures", International Journal of Productivity and Quality Management (2012) Vol.10, No.2, pp. 131-147.
- [7]C Krishnaraj, KM Mohanasundaram, S Navaneethasanthakumar, "Implementation Study Analysis of FTFMEA Model In Indian Foundry Industry", Journal of Applied Sciences Research (2012) Vol.8, No.2, pp. 1009-1017.
- [8]C Krishnaraj, KM Mohanasundaram, "Design and Implementation Study of Knowledge Based Foundry Total Failure Mode Effects Analysis Technique", European Journal of Scientific Research (2012) Vol.71, No.2, pp. 298-311.