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Experimental and Computational Investigations on Piston Coated Externally Scavenged S.I. Engine

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Abstract
Two stroke engines have drawback of more fuel consumption & more exhaust emission, as compared with four stroke engines. Percentage of CO & HC emission is more in two stroke engines. Reductions in fuel consumption can be achieved by a variety of measures, including Improved Aerodynamics, Weight Reductions and Hybrid Power Trains. Significant improvements have been made to improve efficiency of the IC Engine that powers nearly all the world's vehicles. One promising technology for improving IC Engine efficiency, as well as performance and durability, is the Thermal Barrier Coating (TBC). In this study the performance of the engine is studied before and after the application of coating on the piston crown. Required modification has been done in the engine to increase the power and decrease the emission of CO & HC thereby making the engine environment friendly.
Keywords: *SI engines, piston coatings, Thermal Barrier Coating, exhaust emission.*

I. INTRODUCTION

In case of Internal Combustion Engine most of the heat generated during combustion process is absorbed by piston. This is direct heat loss to the piston. This reduces Indicated Power and in turns the performance of Internal Combustion Engine.

Two strokes engines are characterized by high power output and low weight. Two stroke engines have problem of high level of pollutants and higher fuel consumption as compared to 4 stroke engines. These drawbacks of 2 stroke engines are due to short circuiting phenomenon. In short circuiting process, there is a mixing of fresh air fuel mixture (charges) with exhaust gases and nearly 35% of fresh charges are lost through exhaust valve. This loss is dead loss and it should be avoided. Short circuiting can be avoided by adopting proper scavenging system and coating the piston crown.

Using the coated piston the required temperature in the combustion chamber will be maintained. This will reduce the heat loss to the piston. This reduction in the heat loss will be used to burn the unburnt gases there by reducing the polluted exhaust gases. Thermal barrier coatings are most commonly stabilized zirconias such as Yttria- Stabilized Zirconia (YSZ), but other ceramics like Silicon Nitride (SN) have been used. Thermal conductivities (k) have ranged from less than 0.5 W/mK to 10 W/mK and thicknesses have ranged from 0.1 mm to 4.5 mm. Ceramic coatings can be applied by a variety of methods, although thermal spraying techniques such as plasma spray are the most common. A bond layer with a Coefficients of Thermal Expansion (CTE) in between that of the TBC and metal substrate is typically used to improve coating adhesion.

II. MATERIALS AND METHODS

Thermal barrier coatings can be applied in the IC engine to insulate combustion chamber surfaces. The coatings can be applied to the entire combustion chamber or to select surfaces like the piston crown or valves. In this study the TBC coating is applied on the piston crown.

Some of the additional heat energy in the cylinder can be converted into useful work, increasing power and efficiency. Reducing heat transfer also increases exhaust gas temperatures, providing greater potential for energy recovery with a turbocharger or possibly a thermoelectric generator. Additional benefits include protection of metal combustion chamber components from thermal stresses and reduced cooling requirements. A simpler cooling system would reduce the weight and cost of the engine while improving reliability. [4]

Fig 1: Crown COATED PISTON

Thermal barrier coatings are most commonly stabilized zirconias such as Yttria-Stabilized Zirconia (YSZ), but other ceramics like Silicon Nitride (SN) have been used. Thermal conductivities (k) have ranged from less than 0.5 W/mK to 10 W/mK , and thicknesses have ranged from 0.1 mm to 4.5 mm. Ceramic coatings can be applied by a variety of methods, although thermal spraying techniques such as plasma spray are the most common.

A bond layer with a Coefficient of Thermal Expansion (CTE) in between that of the TBC and metal substrate is typically used to improve coating adhesion. At this time TBCs have not been adopted in production engines, but extensive research has been performed. While research has been performed on both diesel and Spark-Ignition (SI) engines, most work has focused on diesel engines because they are not susceptible to knock.

In SI engines, elevated wall temperatures can promote knock, which is auto-ignition of the homogeneous air-fuel mixture in the end gas region. As such, less insulation must be used in SI engines to avoid overly high wall temperatures. The following sub-sections summarize some of the major research that has been performed on TBCs in IC engines. In some cases the insulation was provided by means other than TBCs but with the same effect of raising surface temperatures. [5]

III. EXPERIMENTAL SETUP

FIG. 2:- EXPERIMENTAL SETUP

The selected engine is a Single Cylinder Two Stroke, 150 cc, Crankcase scavenged engine. A rope brake dynamometer which consists of rope, two spring balances as shown in the fig is used for loading the engine to measure brake power.

The air flow is measured with the help of Air box, which pressure is measured with the help of U-Tube manometer, mounted itself on the air box. The fuel measurement is taken with the help of Burette which is calibrated.

PISTON SPECIFICATION

Dia of piston	56mm
Shank length	64mm
No. of ports	5
Pin dia	14mm
No. of piston rings	2
Thickness of piston ring	1.5mm

PISTON COATING SPECIFICATION

Piston with Ni-Cr Coating	100 micron
Piston with Ni-Cr+Ce Coating	50micron+100micron

IV. ANALYSIS

After setting the test rig and various equipments, various results were taken which are shown in previous chapter. In this chapter these results are iterpreted by analysing them with the help of various graphs. With the help of these graph we can also compare the results with the previous engine.

The following graphs were drawn for the performance evaluation of an engine.

1) **Load Vs brake power,**
2) **Load Vs brake specific fuel consumption,**
3) **Load Vs brake thermal efficiency,**
4) **Mass of fuel Vs brake power.**

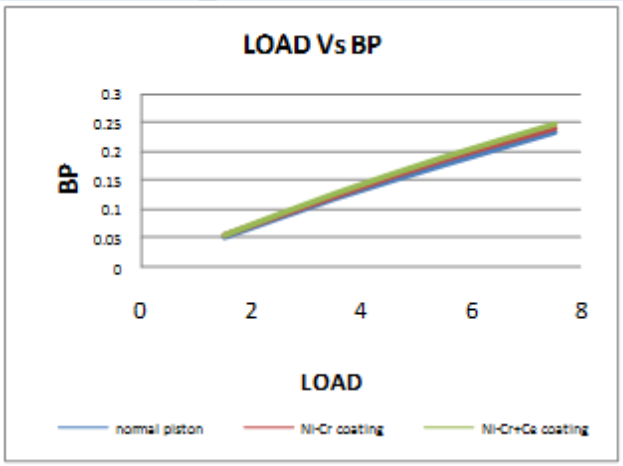

FIG. 3:
LOAD Vs BP

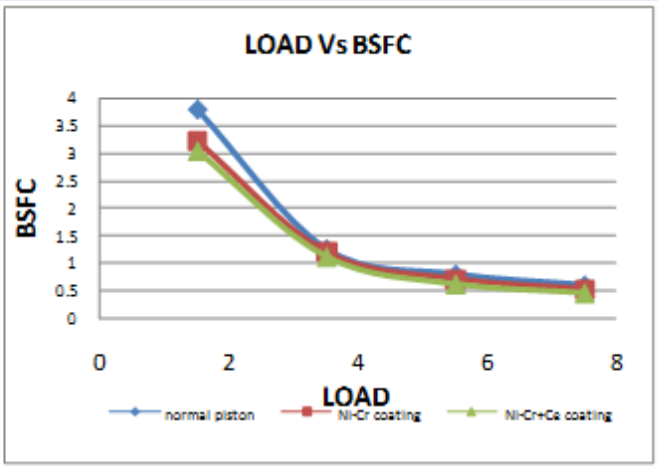

FIG. 4:
LOAD Vs BSFC

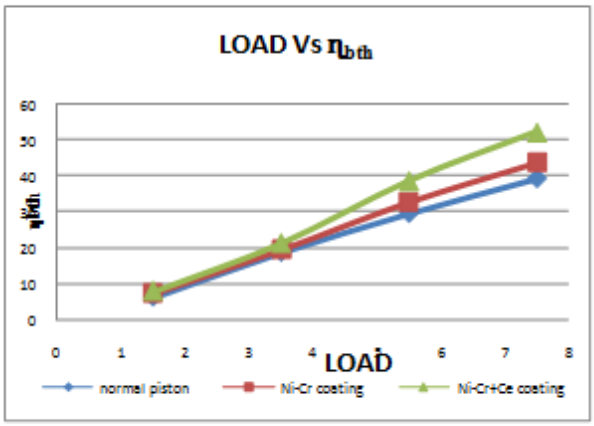

FIG. 5:
LOAD Vs η_{bth}

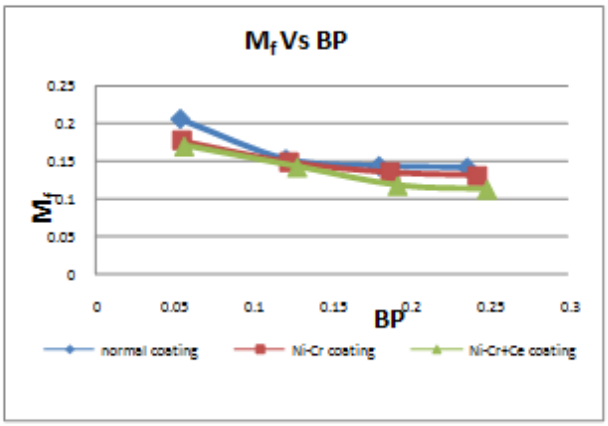

FIG.6:
Mf Vs BP

V. RESULTS & CONCLUSION

There is percentage increase in brake specific fuel consumption, brake thermal efficiency, mass of fuel consumed for different speeds and loads as-

1) Percentage change in brake specific fuel consumption on an average between without coating & coating1 = **11.10%**
2) Percentage change in brake specific fuel consumption on an average between without coating & coating2 = **25.41%**
3) Percentage change in brake specific fuel consumption on an average between coating1 & coating2 = **12.91%**
4) Percentage change in mass of fuel consumed on an average between without coating & coating1 = **8.42%**
5) Percentage change in mass of fuel consumed on an average between without coating & coating2 = **18.93%**
6) Percentage change in mass of fuel consumed on an average between coating1 & coating2 = **9.73%**
7) Percentage change in brake thermal efficiency on an average between without coating & coating1 = **11.14%**
8) Percentage change in brake thermal efficiency on an average between without coating & coating2 = **25.40%**
9) Percentage change in brake thermal efficiency on an average between coating1 & coating2 = **12.73%.**

The performance of an externally scavenged engine will be improved with Ni-Cr-Ce Thermal Barrier Coating, as compared to normal piston & Ni-Cr coating. Therefore Ni-Cr-Ce Thermal Barrier Coating is an effective method to enhance performance of two stroke SI Engine. The engine with TBC piston helps in increasing the power of the engine as stated above. This is because complete combustion of the charge in the combustion chamber which leads to minimization of emission of carbon & hydrocarbon in the exhaust gases.

With this work it is proved that any two stroke engine will fit in the emission norms & hence its production can be started.

Piston coating technology for performance enhancement is a promising technique & it needs further investigation

VI. SCOPE FOR FUTURE RESEARCH

1. Performance characteristic of two stroke engines depends upon the pressure of air with which the exhaust gases are scavenged from the combustion chamber, so in the future it is proposed to evaluate the performance at different air pressure to study scavenging characteristics**.**
2. By using piston coating the effects on combustion can also be analyzed with the help combustion analyzers, so in the future there will be scope in combustion analysis in combustion chamber.
3. Much more work required on the coating on various parts of the engine. In that it is proposed to provide coating on different parts of the engine & then performances can be analyzed.
4. Much more work will be required to determine the optimum level of coating to maximize performances. This optimization includes the various types of coating used & its thickness.
5. Much more work will be required for improving Ceramic bond coat interface region which is weakest region.

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