EXPERIMENTAL ANALYSIS OF THERMAL BARRIER COATING IN TWO STROKE SI ENGINE

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ABSTRACT

The demand for energy is increasing day by day . The world is depending mostly on fossil fuels to face this energy needs. The increase in standard of living demands better mode of transport , hence a large number of automobile companies has been introduced. Automobiles provide better transport but the combustion of fuel in automobile engine creates harmful effluents, which has an adverse effect on water and air. Combustion generated pollution is by far the largest man made contribution to atmosphere pollution. The principle pollutants emitted by the automobile engines are CO,NOX,HC and particulates. The modern day automobiles is a result of several technological improvements that have happened over the years and would continue to do so to meet the performance demands of exhaust- gas Emissions , fuel consumption, power output, convenience and safety . In order to reduce emissions and increasing engine performance , modern car engines carefully designed to control the amount of fuel they burn. An effective way for reducing automotive emission and increase engines performance is accomplished by coating automobile piston head with low thermal conductivity material such as ceramic. This process is known as Thermal Barrier Coating(TBC) and this experimental analysis deals with its analysis.

Key words:-*Low heat reduction engine, SI engine, Piston coating, Thermal Barrier Coating.*

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. 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.[1]

Thermal barrier coating used in piston increasing the brake thermal efficiency and decreasing the specific fuel consumption for light heat rejection (LHR) engine with thermal coated piston compared to the standard engine. There was increasing the NOx emission and O2 for thermal barrier coated engine. However there was decreasing the CO and HC emissions for thermal coated piston engine compared to standard engine.[2]

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. 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.[3]

Ceramics have a higher thermal durability than metals. Therefore it is usually not necessary to cool them as fast as metals. Lower heat rejection from the combustion chamber through thermally insulated components causes an increase in available energy that would increase the in-cylinder work and the amount of energy carried by exhaust gases, which could also be utilized.[4]

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 selected surfaces like the piston crown or valves. The primary purpose of the TBC is to raise surface temperatures during the expansion stroke, there by decreasing the temperature difference between the wall and the gas to reduce heat transfer. 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.[5]

Experimentation

Petrol engine are widely used now-a-days as source of mechanical power. Due to their less weight ratio, they are popularly used for two wheelers and light vehicle like car, scooters etc. their output varies from few horsepower to hundred of horsepower.

SPEIFICATOINS:-

(A) Engine:-

1. No of cylinders : 01
2. Bore :57mm
   Stroke :57mm
3. Capacity :145cc
4. Compression ratio :10:1
5. Maximum torque :1.10 kg-m @ 4000 rpm
6. Power : 4.46kw@5500rpm
7. Speed reduction : 1st Gear = 15.38
   : 2nd Gear = 10.46
   : 3rd Gear = 74:1

(B) Dynamometer: - Rope brake dynamometer

1. Diameter of rope : 25 mm
2. Spring balances : 0-25kg
3. Brake drum pulley diameter :200mm

(C) Control panel

1. Engine controls : Accelerator and Ignition switch
2. Burette : 10mm Diameter
3. Air Box Size : 300*300*300mm

(D) System Constant & Assumption:

1. Calorific Value of Petrol : 44400kJ/kg
2. Density of Petrol : 720kg/m^3
3. Air Density : 1.2 kg/m^3
4. Spefic Heat Of Exhaust : 1.1kJ/kg^0K
5. Compression Ratio :74:1

Engine setup and procedure

Fig. engine setup

Parameters:

Engine is tested in highest gear i.e. third gear

Measurement for fuel consumption is taken for 0.788cc of fuel consumed

Procedure:

Start the engine.

Engine is kept constant running in third gear at constant throttle opening state.

Load the dynamometer for particular reading.

Load is kept at desired value.

Note down the brake drum rpm.

Note down the time taken for 0.785 cc consumption of fuel in burette.

Repeat all the above steps for 5 values of load

Engine modifications:

1. **Piston 1(without coating)**:57mm Diameter

Fig. 4.3.1 piston without coat

2. **Piston 2 (with coating 1)** :-

Top coat : 250 microns

Bond coat : 150 microns

Fig. 4.3.2 piston with coating

3. **Piston 3 (with coating 2)** :-

Top coat : 500 micons

Bond coat : 150 micons

Fig. 4.3.3 Piston with coating 2

Cutting operation are perform on the CNC machining

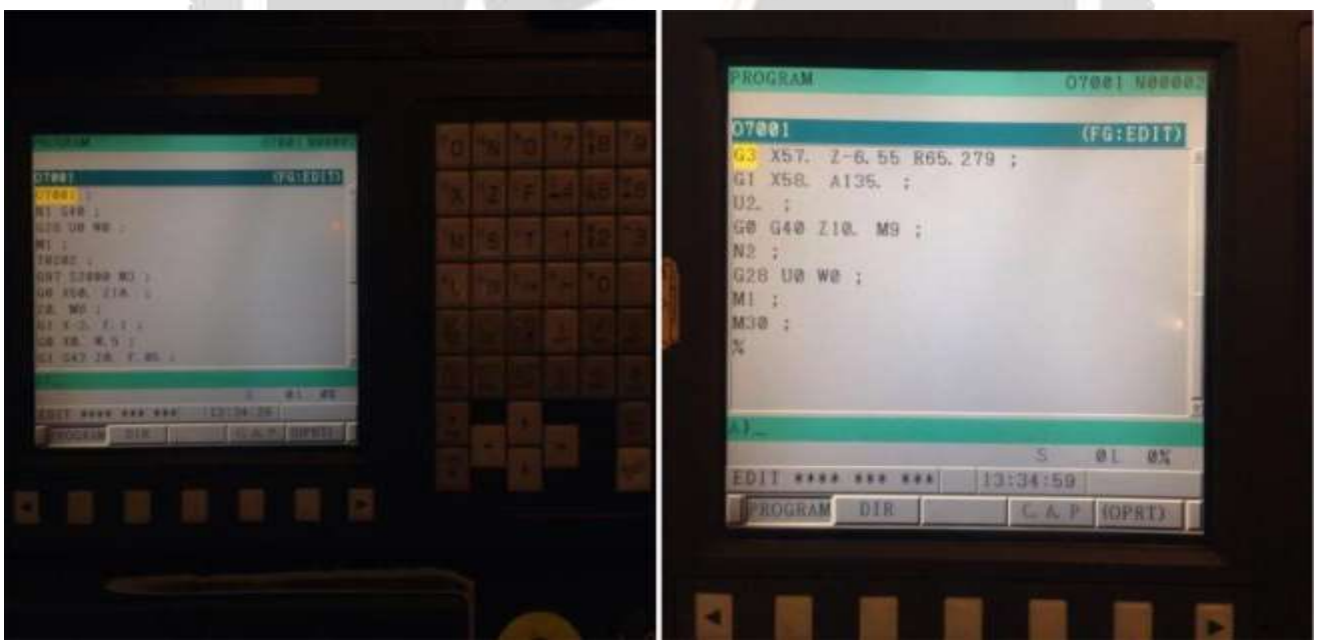


Fig. 4.3.4 CNC machining

Observation Table:

1) Observation table for piston without coating

Particular	1	2	3	4	5
Net Load, W	7	10	11.5	13.5	14.5
Brake Drum speed, N rpm	371	370	374	372	368
Time for of fuel consumption, t sec	5.8	5.8	6.1	6.2	6.2

Observation table no. 1

2) Observation table for piston with coating 1

Particular	1	2	3	4	5
Net Load, W	7	10	12	14	15
Brake Drum speed, N rpm	371	370	371	365	360
aTime for 10 c.c. of fuel consumption , t sec	5.9	6	6.3	6.8	7

Observation table no:2

3) Observation table for piston with coating 2

Particular	1	2	3	4	5
Net Load, W	7	10	11.5	14	15.5
Brake Drum speed, N rpm	374	372	377	375	370
Time for 10 c.c. of fuel consumption, t sec	6	6.4	6.8	7.1	7.5

Observation table no. 3

Calculations

1] For piston without coating

1) Torque

= load (N*m)

= w*9.81*r

Where,

r is drum radius=0.1125m

=15*9.81*0.1125

Torque	=16.55 N.m

2) Power

=2π*N*T

=2π*360*16/60

Power=624 watt

3) Mass flow rate of fuel =density*(v/t)*10^{-6}

=7200*(π/4*7)*(10^{-3}/3600) g/hr

=290.8 g/hr

5) I.P. =mass flow rate*C.V

=290.8*44400

I.P. =3586 watts

5) Brake Thermal Efficiency = B.P. /I.P.

=624/3586

η =17.39%

6) B.S.F.S. = (M_f/B.P.)*10^{-3}

=290.8*10^{-3}/624

B.S.F.S. =466 g/kwhr

2] For piston with coating-1

1) Torque = load (N*m)

= w*9.81*r

=15*9.81*0.1125

Torque =16.55 N.m

2) Power **=2π*N*T**

=2π*360*16/60

Power=624 watt

3) Mass flow rate of fuel =density*(v/t)*10^{-6}

=7200*(π/4*7)*(10^{-3}/3600) g/hr

=290.8 g/hr

5) I.P. =mass flow rate*C.V

=290.8*44400

I.P. =3586 watts

5) Brake Thermal Efficiency = B.P. /I.P.

=624/3586

η =17.39%

6) B.S.F.S. = (M_f/B.P.)*10^{-3}

=290.8*10^{-3}/624

B.S.F.S. =466 g/kwhr

3] For piston with coating-2

1) Torque = load (N*m)

= w*9.81*r

=15.5*9.81*0.1125

Torque =17.10 N.m

2) Power **=2πNT/60**

=2π*370*16/60

3) Mass flow rate of fuel Power=662 watt

=density*(v/t)*10^{-6}

=7200*(π/4*7.5)*(10^{-3}/3600) g/hr

=271.3 g/hr

6) I.P. =mass flow rate*C.V

=318*44400

I.P. =3447.6 watts

5) Brake Thermal Efficiency = B.P./I.P.

=616/3447.6

η =19.2%

6) B.S.F.S. = (M_f/B.P.)*10^{-3}

=271.3*10^{-3}/662

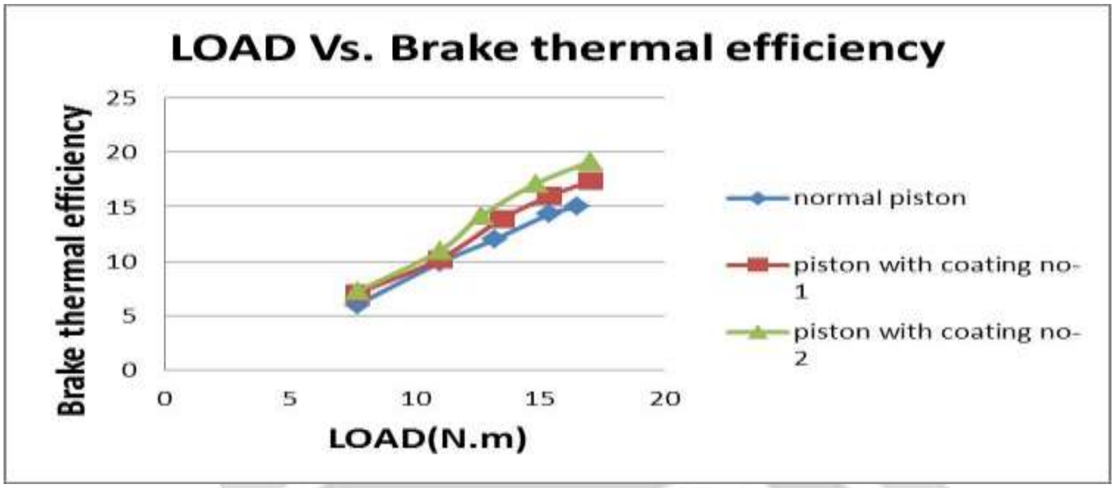
B.S.F.S. =410 g/kwhr

Analysis

Analysis of performance

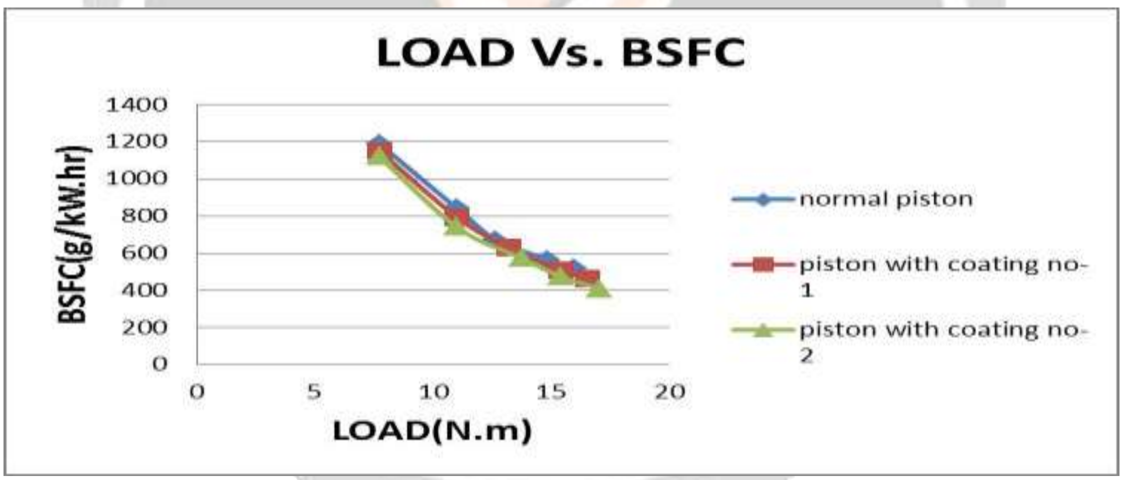
After setting the rig and various equipment, various results were taken which are shown. The chapter these results are interpreted by analysing them with the help of various graphs. With the help of this graph we can also compare the results with the previous engine. The following graphs were drawn for the performance evaluation of an engine.

1) Load vs brake thermal efficiency



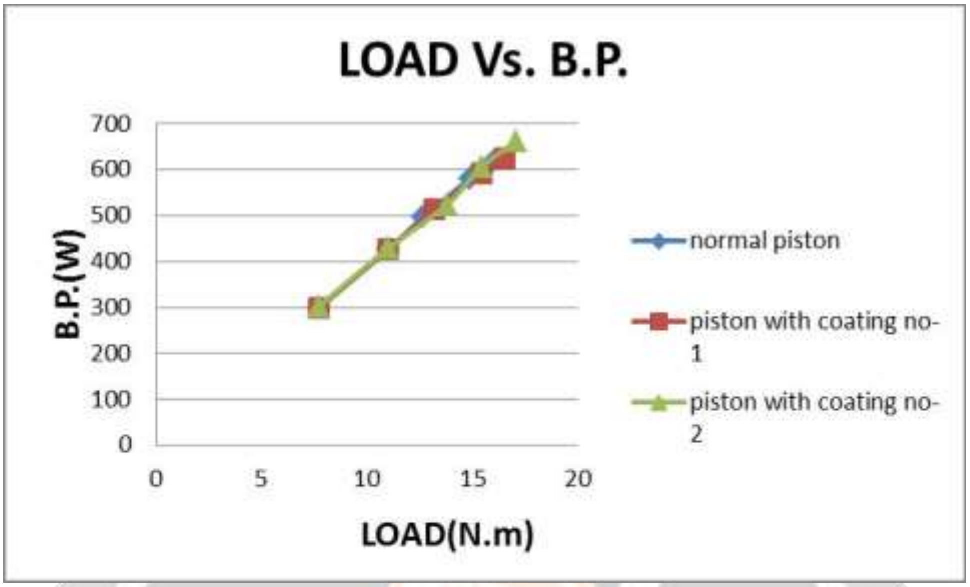
Load vs brake thermal efficiency

2) Load vs brake specific fuel consumption



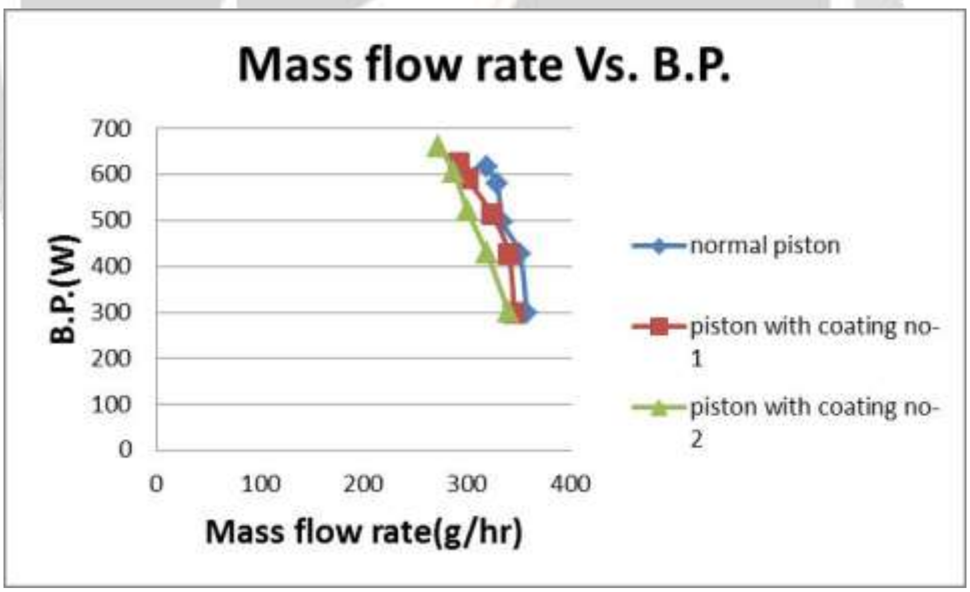
Load vs brake specific fuel consumption

3) Load Vs brake power.



Load vs brake power

4) Mass of fuel Vs brake power



Mass of fuel Vs brake power

Results

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

Break power at same load is increased by **6.9%**

Indicated power at same load decreased by **8-9%**

Fuel consumption decreased by **14%**

Break specific fuel consumption decreased by **15%**

conclusion

The following conclusions are drawn from the experimental investigations of ceramic coated piston and piston without coating.

Composite coating of YSZ and NiCrAlY material is successfully applied on to the piston heads.

No failure symptoms observed on the coating surface is observed.

Large amount of carbon deposits are observed on piston head, completely coveting piston head surface, this may be due to coatings rough surface texture.

Temperature of exhaust gasses observed is higher than previous on normal engine; it indicates there is reduction in heat loss through piston head.

Increase in the break thermal efficiency of engine is observed, increment is about 4%.

From emission point of view no much improvement is observed, it may be due to short circuiting phenomena . This can be improved by improving scavenging efficiency and improved fuel air mixture induction system.

There is trend improvement in performance is observed with increase in coating thick Ness but by small amount

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