Performance Test on Two Stroke Petrol Engine using Combustion Chamber by Ceramic Coated Material

S. Sakthi[1], S.T. Jayasudhakar[2]

[1]Department of Mechanical Engg SMR East Coast College of Engg & Tech, Tamilnadu, India
[2]Department of Mechanical Engg University of Engineering, Thirukkuvalai, Tamilnadu, India

---

Abstract - As per the second law of thermodynamics the efficiency of the engine depends upon the extraction of work against the heat supplied. Minimization of heat rejection leads to increase the work. Heat rejection takes place through the engine piston, valves and cylinder heads to the surroundings. The aim of the study is to minimize this heat rejection to the surroundings. Heat transfer through the engine parts is minimized by applying the thermal barrier coating materials on the top surface of the engine combustion chamber.

In this study an effort is made to reduce the intensity of thermal and structural stresses by using a layer of the ceramic material, like **Yttrium stabilized zirconium** (YSZ) which has low thermal conductivity (1.2-2.2 W/m.k), high thermal resistance, chemical inertness, high resistance to erosion, corrosion and high strength was selected as a coating material for engine component

Key Words*: *YSZ, MgO, CaO, Y2O, NOX, CO, BP, HP, BT, IT

(*Yttrium stabilized zirconium, Calcium Oxide, Magnesium Oxide, Nitrogen Oxides, Yattrium Oxide, Carbon Monoxide, Brake Power Efficiency, Horse Power, Brake Thermal Efficiency, Indicated Thermal Efficiency)*

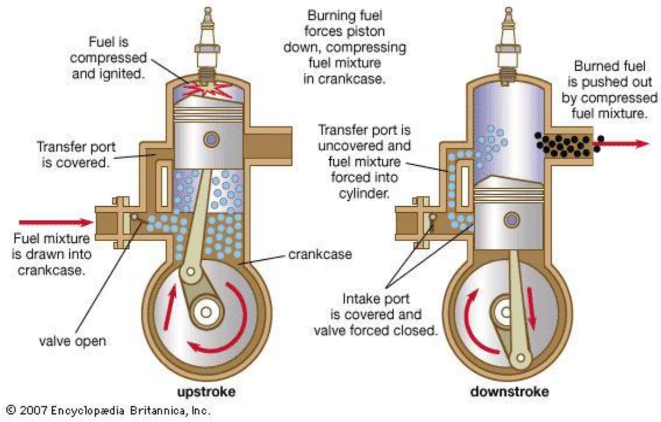
1. INTRODUCTION

Energy conservation and efficiency have always been the quest of engineers concerned with internal combustion engines. Even the petrol engine rejects about two thirds of the heat energy of the fuel, one-third to the coolant, and one third to the exhaust, leaving only about one-third as useful power output. Theoretically if the heat rejected could be reduced, then the thermal efficiency would be improved. Low Heat Rejection engines aim to do this, by reducing the heat lost to the coolant.

1.1 TWO STROKE ENGINES (PETROL ENGINE)

A two-stroke (or two-cycle) engine is a type of internal combustion engine that completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution. This is in contrast to a "four-stroke engine", which requires four strokes of the piston to complete a power cycle during two crankshaft revolutions. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time.

Two-stroke engines often have a high power-to-weight ratio, power being available in a narrow range of rotational speeds called the "power band". Compared to four-stroke engines, two-stroke engines have a greatly reduced number of moving parts.



1.1Upward stroke of the piston (Suction + Compression):

When the piston moves upward it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps the charge of air-fuel mixture drawn already in to the cylinder.

1.2 Downward stroke (Power + Exhaust):

Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke.

2. COMBUSTION CHAMBERS- SI Engines:

The design of combustion chamber has an important influence upon the engine performance and its knock properties. The design of combustion chamber involves the shape of the combustion chamber, the location of the sparking plug and the disposition of inlet and exhaust valves.

Because of the importance of combustion chamber design, it has been a subject of considerable amount of research and development in the last fifty years. It has resulted in raising the compression ratio from 4: 1 before the First World War period to 8: 1 to 11:1 in present times with special combustion Chamber designs and suitable anti-knock fuels.

2.1TYPES OF COMBUSTION CHAMBERS:

1. T-head combustion chamber.

2. L-head combustion chamber.

3. I-head combustion chamber.

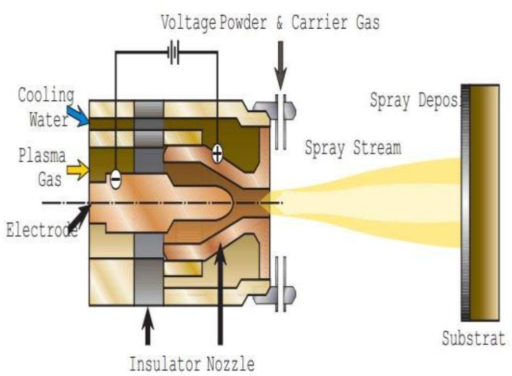
4. F-head combustion chamber.

3. ZIRCONIA MATERIAL:

It is a ceramic material and exists in monoclinic form at temperatures below 11700C. At 23700 C it changes to tetragonal. Structural change is accompanied by volume change .In spite of many advantages the structural changes occurring due to the temperature changes is the main disadvantage of this material. These changes are the root cause for volume changes which may cause cracking or structural failure. Towards certain degree these changes can be mitigated by the additions of some oxides like MgO, CaO, Y2O3 and these oxides will depress allotropic transformation and help in stabilizing the structure at any temperature.

4. COASTING SYSTEM:

4.1Plasma Sprayed Coating: A characteristic of all thermal spray processes is a highly concentrated power source, to which the coating material is fed in the form of powder, wire or rod. The coating material is melted and accelerated to the substrate, forming the coating. The coating is formed of many overlapping splats, solidifying one after another and locking one to another. Due to the high kinetic energy of the droplets, the splats spread over the substrate, forming a pancake. It is widely used for the production of TBCs.



5. EXPERIMENTAL SETUP:

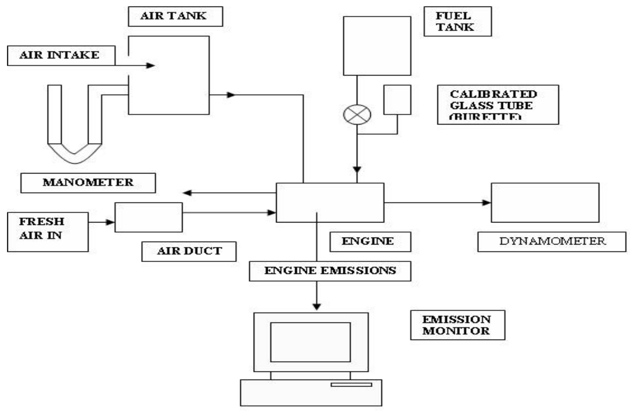


Table -1: ENGINE SPECIFICATION

	Stroke	=	2
	Bore	=	46mm
	Stroke length	=	42mm
	Displacement	=	69.3cc
	MAX.POWER@5000rpm	=	2.61kw
	torque@3750rpm	=	5.0Nm
	Compression ratio	=	8.3:1

6. TESTING ARRANGEMENTS:

The experimental tests are carried out by constructing a test rig as shown in Figure.

The following instruments

- Manometer
- stopwatch surge tank
- Thermocouple
- Spring balance
- Brake drum
- Burette

Table -2.PERFORMANCE STUDIES ON UNCOATED ENGINE

S.No	BP(Kw)	BT(%)	IT(%)	Mech(%)	Vol(%)
1.	0	0	48.5	0	84
2.	0.1	3.2	50.5	6.3	85

3.	0.2	5.7	48.2	12	90
4.	0.3	8.5	50.8	16.7	87
5.	0.4	9.9	46.9	21	86
6.	0.5	12.4	49.6	25	86
7.	0.6	14.2	49.8	28.6	88
8.	0.7	16.9	53	31.8	88
9.	0.8	18.5	53.2	34.8	86
10.	0.9	20.5	54.5	37.5	88
11.	1.0	21.6	53.9	40	88
12.	1.1	22.4	53.1	42.3	83
13.	1.2	22.2	50	44.4	89
14.	1.3	23.7	51	46.4	84
15.	1.4	23.7	49.2	48.3	89
16.	1.5	24.6	49.2	50	85

Table -3. PERFORMANCE STUDIES ON COATED ENGINE:

S.No	BP(Kw)	BT(%)	IT(%)	Mech(%)	Vol(%)
1.	0	0	62.3	0	75
2.	0.1	3.03	60.8	5	81
3.	0.2	6.07	63.8	9.5	80
4.	0.3	9.5	69.4	13.6	72
5.	0.4	11.7	67.3	17.4	89
6.	0.5	14.6	70.2	20.8	74
7.	0.6	16.9	70.6	24	88
8.	0.7	20	73.4	27	85
9.	0.8	22.6	76.3	30	91
10.	0.9	24.6	76.5	32	89
11.	1.0	27.3	79	34	84
12.	1.1	29.1	79.4	37	83
13.	1.2	31.7	82	39	80
14.	1.3	33.3	82	40.6	79
15.	1.4	34.7	82	43.4	80
16.	1.5	36.1	82	44	83

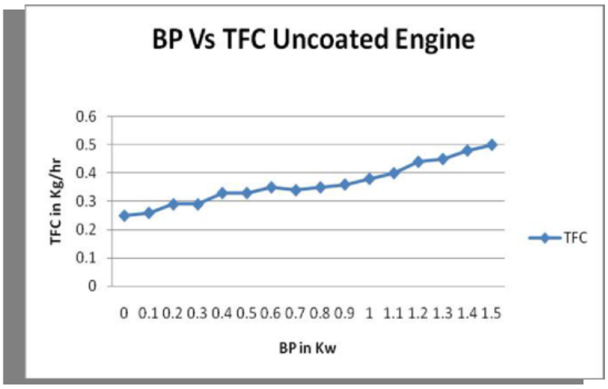


Chart -1: BP Vs TFC Uncoated Engine

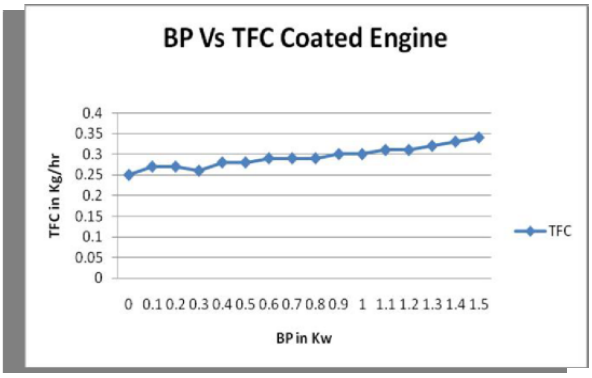


Chart -2: BP Vs TFC coated Engine

Table -4. TEMPERATURE MEASUREMENTS:

Duration(minutes)	Temperature(°C)			
	Coated Engine		Uncoated Engine	
	Head	Cylinder	Head	Cylinder
10	54.6	57.6	103.2	97.2
20	79.2	81.6	110.4	102
30	84.6	97.2	113.4	106.8
40	94.2	93	118.8	110.4
50	103.2	94.8	122.4	118.8
60	103.2	94.8	122.4	118.8

Table -5. EMISSION LEVELS:

Speed(rpm)	CO(vol%)		HC(ppm)	
	Uncoated	Coated	Uncoated	Coated
0	2.6	2	1250	900
500	2.67	2.05	1500	900
1000	2.7	2.1	1750	900
1500	2.75	2.25	2100	950
2000	2.8	3	2500	1000
2300	3.5	3.2	2900	1050

Fig -1: Coated meterial

Fig -1: Experimental Setup

6. CONCLUSIONS

As the zirconia is a low thermal conductivity material, it decreases the heat loss from the cylinder to the environments. Therefore the efficiencies are increased and the emissions are reduced because of various chemical reactions takes place inside the cylinder at high temperature. Brake thermal efficiency and mechanical efficiency of coated piston are increased by the average value of 9% and 25% respectively. 7% reduction in total fuel consumption and 6% reduction in specific fuel consumption were achieved with the coated piston. 14% of NOX emissions were reduced due to coating because of nitrogen has observed by zirconia. 23% of unburned HC emissions were reduced by using the coated piston. CO emissions are reduced by 48% because of at high temperature C easily combines with O2 and reduces CO emission.

7. RESULTS AND DISCUSSION

The low heat rejection (LHR) engine concept is based on minimising this heat rejection to the coolant and recovering the energy in the form of useful work. Zirconia is a low thermal conductivity material. It will act as a barrier for the heat transfer to the surroundings from the engine's combustion chamber and reduces the heat loss from the engine.

8. REFERENCES

[1] Mast Durat,Murat Kapsiz,Ergun Nart, Ferit Ficci and AdnanParlak(2011) 'The effects of coating materials in spark ignition engine design' ELSEVIER.

[2] Siew Hwa Chan(2000) 'Performance and emissions characteristics of a partially insulated gasoline engine', ELSEVIER.

[3] Idris Cesur (2011) 'The effects of modified ignition timing on cold start HC emissions and WOT performance of an LPG fuelled SI engine with thermal barrier layer coated piston' International Journal of the Physical Sciences Vol. 6(3), pp. 418-424, 4 February.

[4]Ramesh B.Poola,B Nagalingam and K.V.Gopalakrishnan "Performance of Thin-Ceramic- Coated Combustion Chamber with Gasoline and Methanol as Fuels in a Two-Stroke SI Engine". SAE Technical Paper 941911, 1994.

[5]Senthilkumar Tamilkolundu and Kumaragurubaran Balasubrmanian, (2012) "Evaluation of engine performance and emission characteristics of zirconia coated piston surface in SI engine' Journal of Environmental Research And Development Vol. 7

[6] Vinoth Kumar yadav and yogesh Mishra Design and Structural Analysis of Ceramic Coated Petrol Engine Piston using Finite Element Method,Vol 4,ISSUE 6, June 2015.