PERFORMANCE AND EMMISSION CHARACTERISATION OF 4-STROKE DIESEL ENGINE USING ZIRCONIUM DIOXIDE (ZRO2) COATED PISTON OF VARIOUS THICKNESS.

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Abstract
It is ended that from past few decades the consumption of fossil fuel as measuring at faster rates in order to satisfy the needs of mankind. Many researches are working in the process of measuring the efficiency of the engine. Thermal coating is a process applying a layer of coated materials on the surface of any metallic part. In this project working of the zirconium di oxide (ZrO_2) is used on coated material and NiCrAl is used on subtract material. A 0.1mm layer of zirconium di oxide is coated on top surface of the piston then the performance of the IC engine is evaluated. The performance parameter of the coated piston is compared with performance parameter of uncoated piston. The material efficiency and Brake power of the coated piston is expected to increase, since the melting point temperature of zirconium di oxide is more than 2500^{o} Celsius.

Keywords: Thermal coating, Plasma spray process, ZrO_2 based coatings

Introduction

Thermal Coating

Thermal barrier coatings are designed to protect metal structural components from extreme elevated temperatures, thereby reducing stress and fatigue and increasing the part's lifespan. In order to provide such a high level of protection, thermal barriers incorporate several key components.

Plasma Spray Process

Table No 1 shows The Plasma Spray Process is basically the spraying of molten or heat softened material onto a surface to provide a coating. Material in the form of powder is injected into a very high temperature plasma flame, where it is rapidly heated and accelerated to a high velocity.

Table No.1:Details of Plasma Spray Process

Particulars	**Details**
Gun	3mb
Nozzle	GH Type Nozzle
Argon pressure Flow rate – 80 to 90 SCSH	100 to 120 PSI
Hydrogen Pressure Flow rate -15 to 18 SCSH	50PSI
Current and Voltage	500 Amps and 65 to 70 volts
Powder speed	0.62 to 0.75 gm/sec
Spray distance	0.05-0.07 meters

Note:
PSI = pounds per square inch
SCSH =standard cubic seed per hour

Zirconium Dioxide

Table No.2 Zirconium dioxide (ZrO_2), is a white crystalline oxide of zirconium. Its most naturally occurring form, with a monoclinic crystalline structure, is the mineral baddeleyite. A dopant stabilized cubic structured zirconia, cubic zirconia, is synthesized in various colors for use as a gemstone and a diamond simulant.

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Table No.2: Mechanical Properties of Zirconium Di Oxide

Mechanical properties	**Amount**
Density	6.05g/cm3
Hardness	1200HV
Bend strength	900-1200 MPa
Compressive strength	2000 MPa
Fracture toughness	7-10 MPa

Four Stroke Diesel Engine

Fig:1 shows Four stroke diesel engine is also known as the compressed ignition (CI) engine since in this kind of engine the combustion occurs due to the compressing a air more than fuel self-ignition temperature. The compression ratio of this engine is higher as compared to SI engine and it not uses the spark plug.

Fig:1 Four Stroke Diesel Engine

Procedure

Check all electrical connections and check Diesel and oil in the engine. Start the engine by manual cranking and by operating decompression lever. Allow the water supply and allow the engine to stabilize at rated speed d. Now take readings of manometer reading and time for 5ml of fuel consumption. Load the engine by turning the wheel on the brake drum, so that rope will be tightened. Note down readings on the spring scale, manometer reading, time for 5ml of fuel consumption and speed. Continue loading the engine step by step for different load condition. At full load records the temperatures. Tabulate all the readings and calculate BP, IP, mechanical efficiency Brake thermal efficiency, indicated thermal efficiency, Brake specific fuel consumption, indicated specific fuel consumption and volumetric efficiency. Plot the graph mf v/s BP, Qin v/s BP, SFC v/s BP, □mech v/s BP, □bth v/s BP, □ith v/s BP, □vol v/s BP.

Results and Discussions

Brake power (KW)VS Indicated Thermal Efficiency (%)

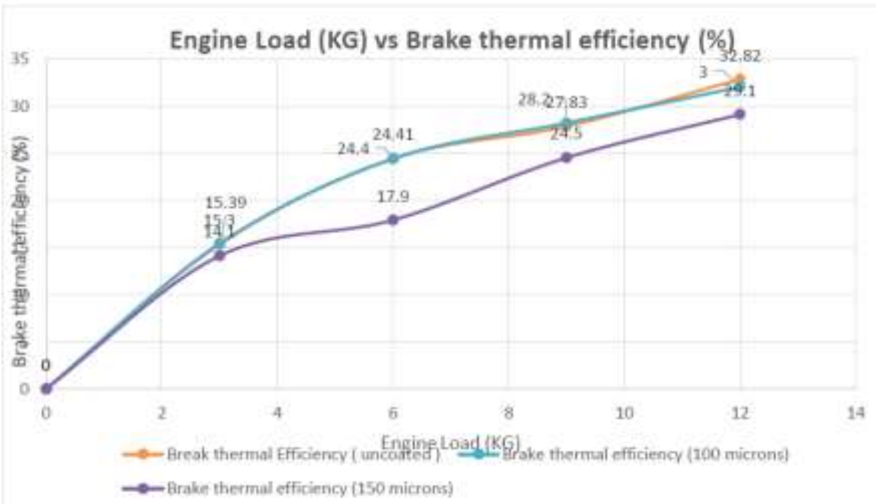

Fig:2 Brake power (KW)VS Indicated Thermal Efficiency

The Fig 2 shows Brake Power V/S Indicated thermal efficiency of uncoated (Al) and Coated piston

(ZrO2+Al) of thickness 100 microns and 150 microns. The test was done under following loads 0 kg,3kg,6kg,9kg and 12kg.From the above figure indicates the variation of indicated thermal efficiency V/S brake power. It is evident from the above graph, the indicated thermal efficiency of 100 microns coated piston is more compared to uncoated and coated piston of 150 microns. Due to increase in combustion the total amount of Indicated power produced in coated piston is increased compared to uncoated piston. The indicated thermal efficiency of 100 microns coated piston at full load 3.1 KW is increased by 2.2% compared to uncoated piston[1]. The uncoated piston delivers less performance where comparing to coated 100 microns piston.

Engine load Vs Break thermal efficiency

The fig3 shows Engine load Vs Break thermal efficiency of uncoated (Al) and coated (ZrO2+Al) pistons thickness 100 microns and 150 microns. The test was done under following loads like 0kg,3kg,6kg,9kg,12kg. The break thermal efficiency of 100 microns coated piston and uncoated piston at full load conditions are Similar. The break thermal efficiency of coated piston with 150 microns thickness is reduced by 10% compare to uncoated piston. Therefore, from break thermal efficiency point of view the coated piston of 100 microns is having better performance results compare to 150 microns piston.

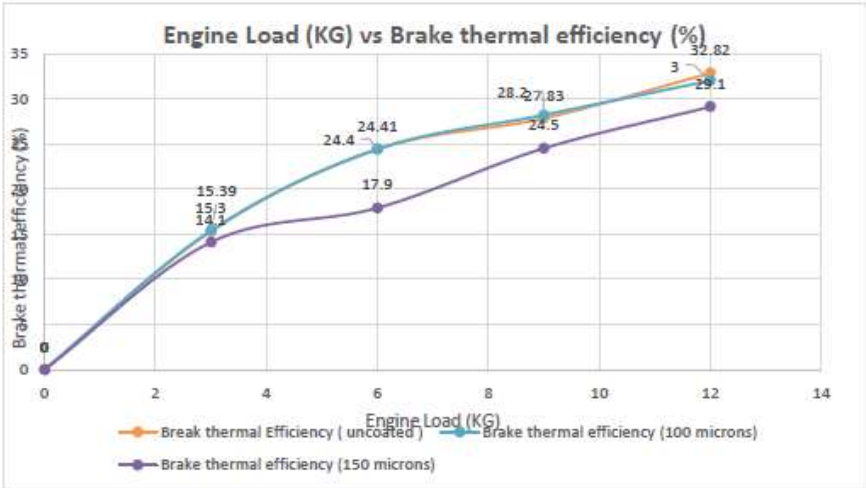

Fig:3 Engine load Vs Break thermal efficiency

Break Power Vs Total fuel consumption

The fig:4 shows Break Power Vs Total fuel consumption of uncoated (Al) and coated (ZrO2+Al) piston thickness 100 microns and 150 microns. The test was done under following loads like 0kg,3kg,6kg,9kg, 12kg.The mean fuel consumption of 100 microns coated piston is consuming 4.05% lesser fuel compare to uncoated piston between 0 to full load condition. But the fuel consumption of 150 microns coated piston is increased on average when compared to uncoated piston by 12.94%. Therefore, from fuel consumption point of view 100 micron coated is consuming less fuel compared uncoated piston and also break power produced by coated piston is increased [2]. From performance wise 100 and 150 microns coated piston is better compared to uncoated piston.

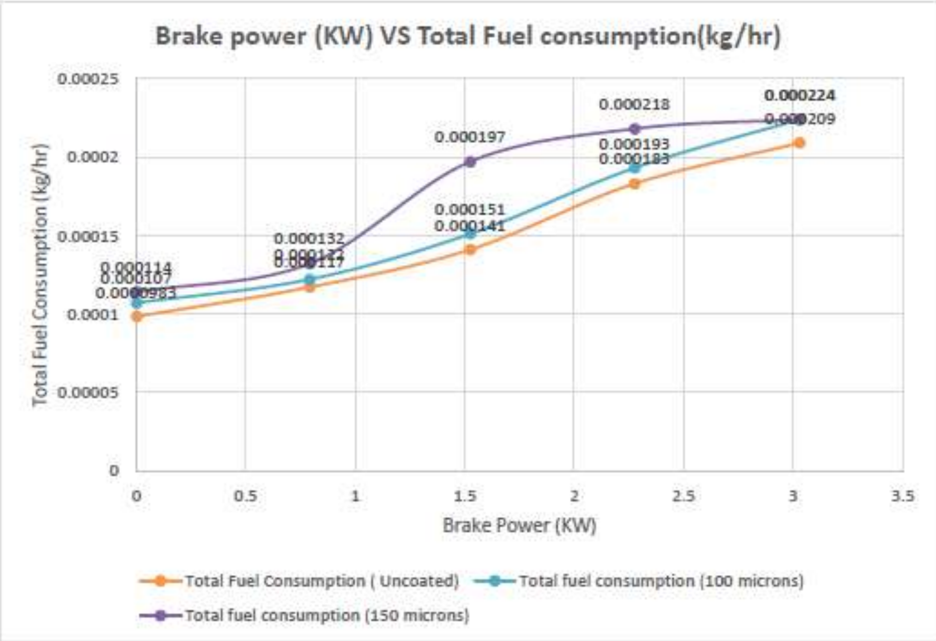

Fig:4 Break Power Vs Total fuel consumption

Brake Power vs Indicated Specific Fuel Consumption

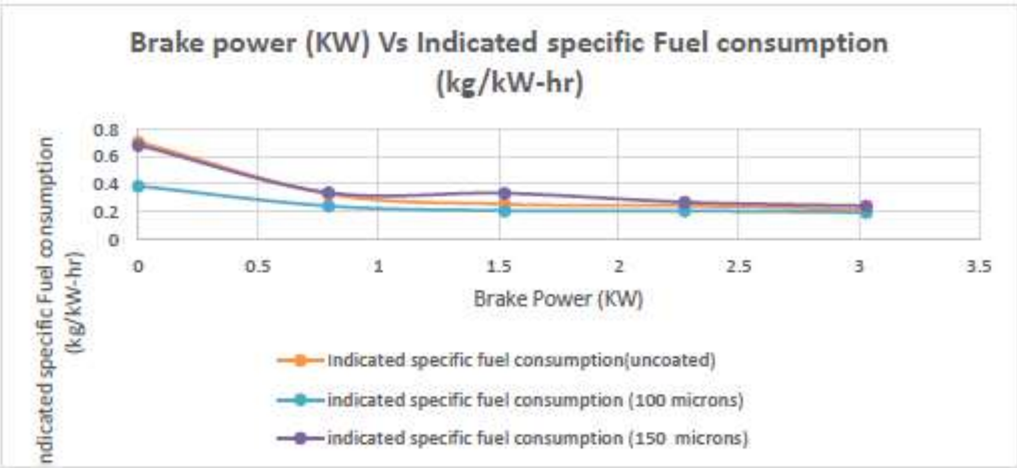

Fig:5 Brake Power vs Indicated Specific Fuel Consumption

The figure5 shows Brake Power vs Indicated Specific Fuel Consumption of uncoated piston and coated pistons of thickness 100 microns and 150 microns. The test was done under following loads 0kg, 3kg, 6kg, 9kg and 12kg. The average Indicated Specific Fuel Consumption of 100 microns and 150 microns coated piston is less compared to uncoated piston by 11% and 9% respectively[3]. Therefore, from Indicated Specific Fuel Consumption, it is evident that 100 microns coated piston is performing better compared to uncoated and 150 coated pistons.

Carbon Monoxide Emissions

The below fig 6 shows the variations of Carbon monoxide emission in Four Stroke Diesel Engine. It represents the emission of engine at various thicknesses of piston (Uncoated, Coated (ZrO_2+Al) 100, Coated (ZrO_2+Al) 150). It can easily be understood from graph that ZrO_2+Al (100 microns) emits less CO comparing to its respective alternate, as it emits 0.14 weighted % volume of CO. However, the other thickness of piston ZrO_2+Al (150 microns) emission volume of CO is more compared to uncoated and 100 microns[4]. But the uncoated piston emission volume of CO which is high compared to that of 100 microns coated pistons. Hence, it can be concluded that emission of CO is less in 100 micron coated pistons when compared to uncoated piston.

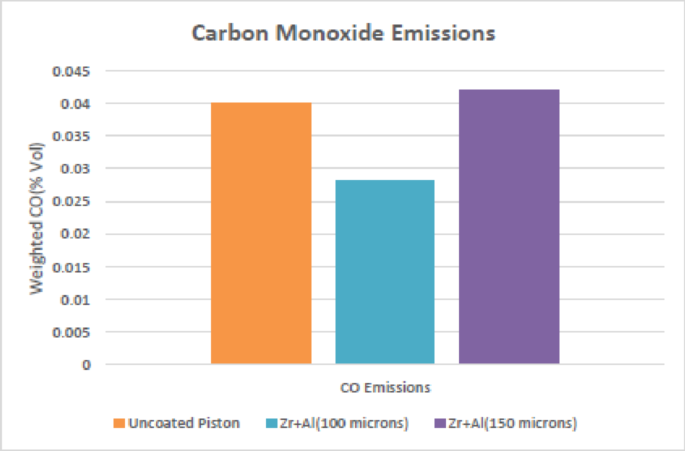

Fig:6 Carbon Monoxide Emissions

Carbon dioxide Emissions

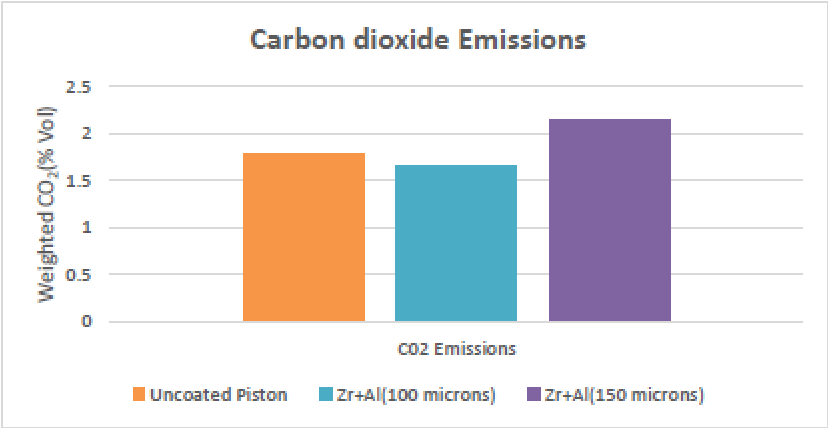

Fig:7 Carbon Di oxide Emissions

The above fig 7 shows the variations of Carbon dioxide emission in Four Stroke Diesel Engine. It represents the emission of engine at various thicknesses of piston (Uncoated, Coated (ZrO2+Al) 100, Coated (ZrO2+Al) 150). It can easily be understood from graph that ZrO2+Al (100 microns) emits less CO2 comparing to its respective alternate, as it emits 6.7 weighted % volume of CO2. However, the other thickness of piston ZrO2+Al (150 microns) emission of CO2 is more compared to 100 micron and uncoated position, But the uncoated piston emission volume of CO2 which is high compared to that of 100micron coated pistons [5]. Hence, it can be concluded that emission of CO2 is less in 100 micron coated pistons when compared to uncoated piston.

Hydrocarbons Emissions

The below fig 8. shows the variations of Hydrocarbons emission in Four Stroke Diesel Engine. It represents the emission of engine at various thicknesses of piston (Uncoated, Coated (ZrO2+Al) 100, Coated (ZrO2+Al) 150). It can easily be understood from graph that ZrO2+Al (100 microns) emits less HC comparing to its respective alternate, as it emits 10.6 PPM volume of HC. However, the other thickness of piston ZrO2+Al (150 microns) emits 13.4 PPM volume of HC. But the uncoated piston emits 12.6 PPM volume of HC which is high compared to that of coated piston (100 microns). Hence, it can be concluded that emission of HC is less in coated piston (100 microns) when compared to uncoated piston[6]. Whereas the emission of coated piston (150microns) is more than the emission of the coated piston (100 microns) and uncoated piston.

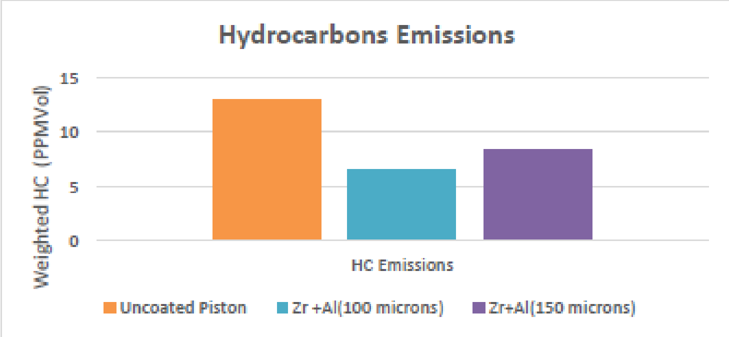

Fig:8 Hydrocarbons Emissions

Nitrogen Oxides Emissions

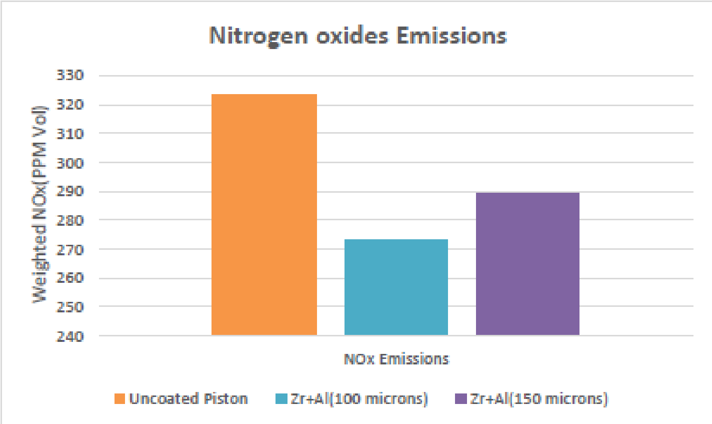

Fig:9 Nitrogen Oxides Emissions

The fig 9 shows the variations of Nitrogen oxide emission in Four Stroke Diesel Engine. It represents the emission of engine at various thicknesses of piston (Uncoated, Coated (ZrO2+Al) 100, Coated (ZrO2+Al) 150). It can easily be understood from graph that ZrO2+Al (100microns) emits less NOx comparing to its respective alternate, as it emits 1477 PPM volume of NOx. However, the other thickness of piston ZrO2+Al (150 microns) emits 1555 PPM volume of NOx. But the uncoated piston emits 2033 PPM volume of NOx which is high compared to that of coated pistons. Hence, it can be concluded that emission of NOx is less in coated pistons when compared to uncoated piston.

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Conclusion

With the advent of new TBC materials in order to improve the performance and emission characteristics of IC Engines, this study proposed an alternate material 100 micron coated (ZrO2+Al) piston. Further, the proposed material is compared with other two uncoated (Al) and 150 microns coated (ZrO2+Al) piston. Therefore, we can conclude that 100 micron (ZrO2+Al) piston is probably good compared to uncoated (Al) and 150 micron coated (ZrO2+Al) piston.

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