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EFFECT OF THERMAL BARRIER COATING ON DIESEL ENGINE PERFORMANCE

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ABSTRACT:
Only around one-third of the diesel engine's thermal energy is used as useful power output after two-thirds of it is rejected, one-third goes to the coolant, and one-third goes to the exhaust. The thermal efficiency would theoretically increase if the amount of heat rejected could be decreased, at least as far as the second law of thermodynamics would allow. By lowering the amount of heat lost to the coolant, Low Heat Rejection (LHR) engines seek to achieve this. The LHR engine is a diesel engine that has ceramic insulation on the walls of its combustion chamber. Thermal barrier coatings based on ceramic are being studied as potential materials for coating engine parts that are exposed to high temperatures during operation. A review of the impact of specific ceramic coatings on low heat rejection engines is attempted in this publication. Ceramics are often superior thermal insulators and more resistant to oxidation, corrosion, and wear than metals. Compared to metals, they are more thermally durable. Ceramics with low thermal conductivity can be utilized to regulate heat flow and temperature distribution in a construction. Improved combustion, lower emissions, and increased engine thermal efficiency are all possible with these thermal barrier coatings (TBC). The current communication examines the benefits and drawbacks of ceramic coating performance in this regard. The outcomes are examined.

Keywords:
Diesel engine, Low Heat Rejection (LHR) engines, Thermal barrier coatings (TBC), Low thermal conductivity.

1. INTRODUCTION:

Engineers have been looking for the optimum materials for rings, pistons, and cylinders for the past 100 years. Cast iron was the material of choice for vehicle engines in their early years. Cast iron was used by engineers to make cylinders, rings, and pistons. For cylinders and rings, cast iron was suitable, but because cast iron pistons were heavy, aluminium pistons were used instead because of the alloy's reduced density. The performance of a TBC system as a liner in an IC engine mostly depends on top coat, which is why aluminium pistons are still used in the majority of automobile engines today due to the combination of cast iron cylinders and rings.The piston, cylinder liner and valves are the important parts of the internal combustion engine to be given more attention Gains in gas temperatures were approximately 2000 °C for superalloy development, 5000 °C for air-cooled systems, and 3000 °C for thermal barrier coatings. As a result, the majority of the hot end of modern gas turbine engines is composed of super alloys with air cooling, and more and more parts now have thermal barrier coatings. The liner in a baseline engine experiences extreme wear at high combustion temperatures, leading to liner seizure. The engine's thermal efficiency drops as a result of heat loss through the cylinder walls. Reduction of emissions from diesel engine is becoming increasingly important, because of promulgation of stringent emissions legislation.

To increase wear resistance, thermal efficiency, and minimize pollutants in the exhaust of the engine, a thermal barrier and wear resistant coating is applied to inner walls of the cylinder which replaces conventional liner. In the current situation, thermal barrier coating, or TBC, is a novel method. TBC is a thin ceramic coating that is applied to the valves, cylinder cover, cylinder walls, and piston crown of combustion chambers. The current issues might be partially resolved by employing this method. The use of thermal barrier coatings to provide thermal insulation for heat engine components is growing in significance. In addition to lowering component structural temperature, thermal insulation also lessens in-cylinder heat transfer from the engine combustion chamber. Heat containment also increases cylinder work and provides a greater precise

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temperature for energy recovery. Greater durability will be achieved by lowering the structural temperature of the component.

2. THE OBJECTIVE OF CONDUCTING A PERFORMANCE TEST:

I. Choosing the material for the thermal barrier coating.
II. Look for a sector of the economy that has the capacity and availability to spray the coating substance thermally.
III. Buying the necessary engine spare parts from a nearby company that meet the same criteria.
IV. Using the plasma spray coating process to apply YSZ to the spare parts.
V. Running the experiment on an uncoated diesel engine with variable load circumstances and a constant speed.
VI. Replacement of uncoated cylinder head and piston with coated ones by disassembly of the engine head, cylinder and piston.
VII. Performing the experiment on coated diesel engine under constant speed and varying load conditions.
VIII. Comparison of the performance characteristics of un- coated and coated diesel engine through graphical representation.

3. THERMAL SPRAY COATING:

Coating methods known as thermal spraying involve spraying hot or melted materials onto a surface. Electrical (plasma or arc) or chemical (combustion flame) methods are used to heat the "feedstock" (coating precursor). Compared to other coating techniques like electroplating, physical, and chemical vapor deposition, thermal spraying may produce thick coatings (about 20 micrometers to several millimeters, depending on the method and feedstock) over a vast area at a high deposition rate. Metals, alloys, ceramics, polymers, and composites are among the coating materials that can be applied by thermal spraying. Thermal spraying often uses electrical arc discharge or combustion as its energy source. The buildup of many sprayed particles creates the resulting coatings. Because the surface might not heat up much, flammable materials could be coated.

4. PERFORMANCE TESTS:

1. Brake Power.
2. Mass of fuel consumed.
3. Indicated power
4. Brake thermal Efficiency.
5. Air fuel ratio
6. Indicated thermal Efficiency.

Formulae used:

1. Brake Power (BP) = 2*π*N*W*9.81*((D+d)/2)/60000 kW
2. Total Fuel Consumed Kg per hour (mf) = (10/t)*ρ*3600/1000 kg/hr
3. Brake Specific Fuel Consumption (bsfc)= mf /CV kg/kW-hr
4. Heat Input (Q)=mf*CV kW
5. Indicated power (ip) = BP + FP kW
6. Where FP-frictional power (kW) Frictional power is obtained by Williamson line method
7. Brake Thermal Efficiency (ŋbth) =(B.P/Q)*100
8. Indicated Thermal Efficiency (ŋith)=(ip/Q)*100
9. Mechanical Efficiency (ŋmech)= (BP/ip)*100

5.

6. RESULTS AND DISCUSSIONS:

Performance Charts for uncoated diesel engine

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LOAD Vs TOTAL FUEL CONSUMPTION

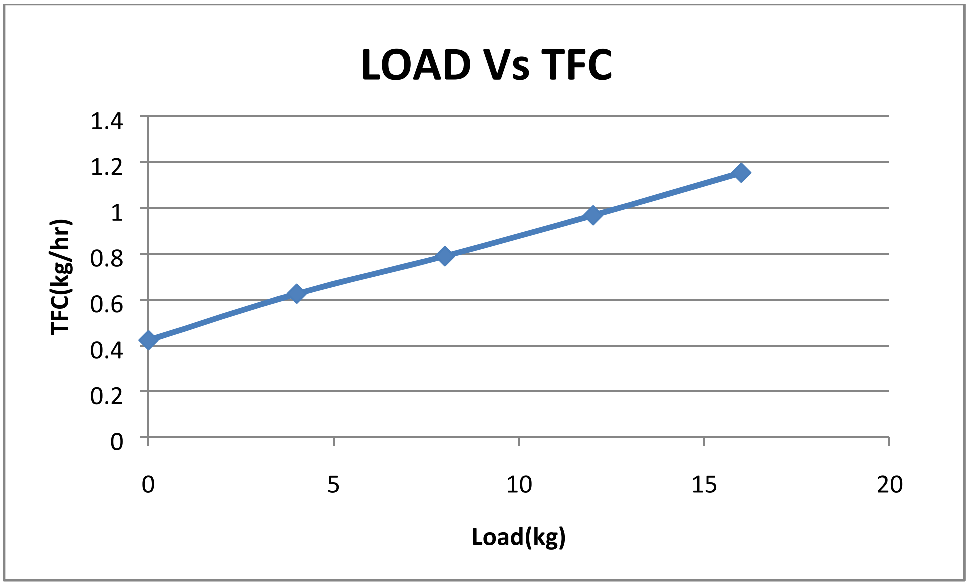

Fig 6.1 Load Vs TFC of uncoated diesel engine

The above fig 6.1 shows the relation between Load Vs TFC of uncoated diesel engine. The Load increases the fuel consumption increases.

LOAD Vs BRAKE THERMAL EFFICIENCY

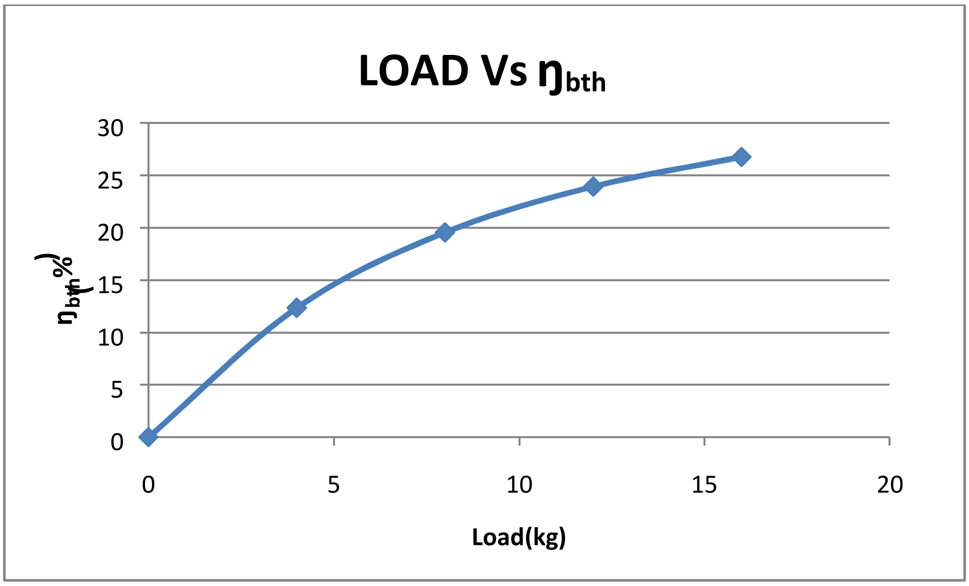

Fig 6.2 Load Vs ŋbth of uncoated diesel engine

The above fig 6.2 shows the relation between Load Vs Brake thermal efficiency of uncoated diesel engine the load increases the brake thermal efficiency increases.

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BRAKE POWER Vs BRAKE THERMAL EFFICIENCY

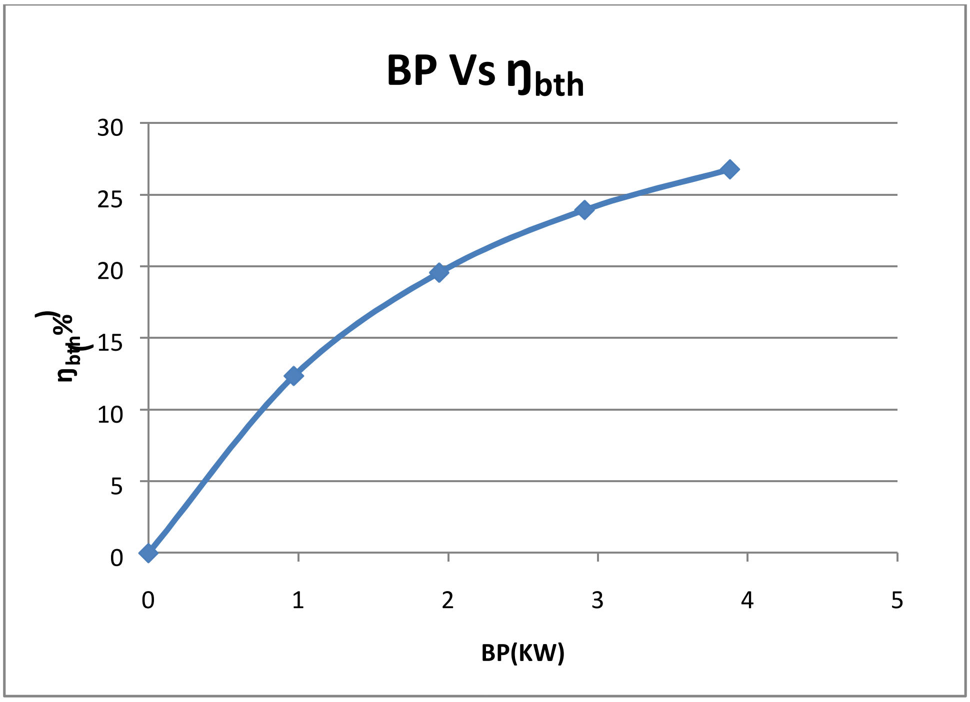

Fig 6.3 BP Vs ŋbth of uncoated diesel engine

The above fig 6.3 shows the relation between BP and brake thermal efficiency of uncoated diesel engine the BP increases break thermal efficiency increases.

BRAKE POWER Vs BRAKE SPECIFIC FUEL CONSUMPTION

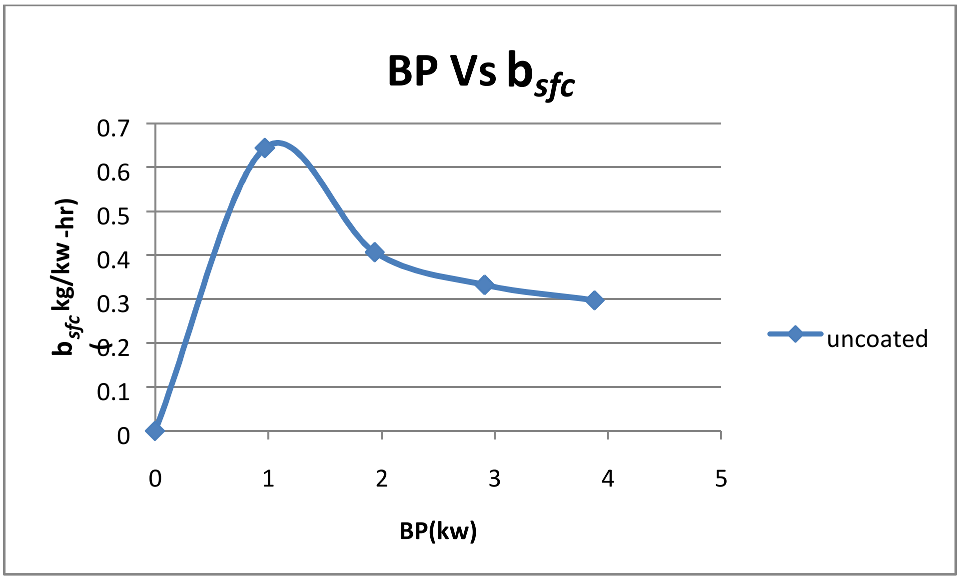

Fig 6.4 BP Vs b_{sfc} of uncoated diesel engine

The above fig 6.4 shows the relation of BP Vs Brake specific fuel consumption of uncoated diesel engine. The fuel consumption increases and decreases at higher load.

Performance Charts for coated diesel engine

LOAD Vs TOTAL FUEL CONSUMPTION

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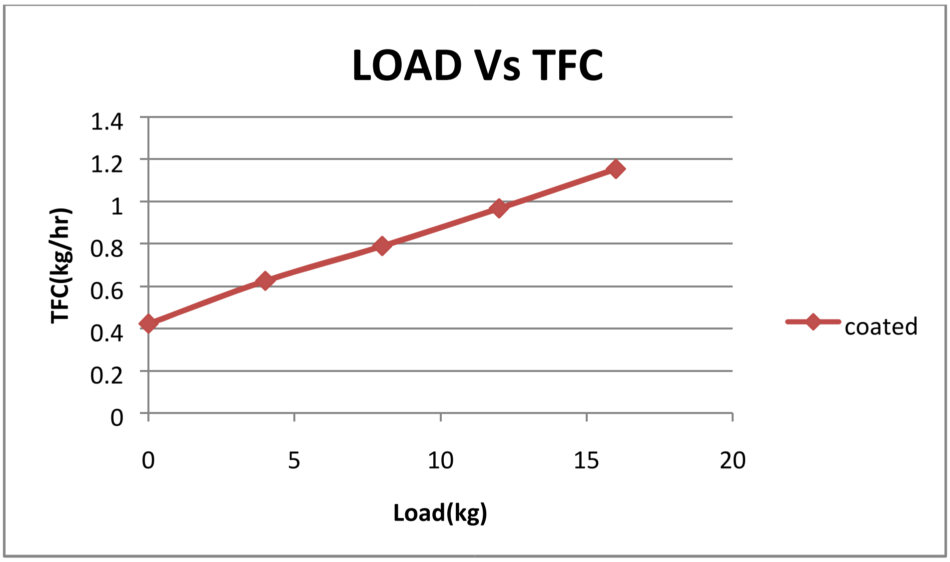

Fig 6.5 Load Vs TFC of coated diesel engine

The above fig 6.5 shows the relation of Load Vs TFC of coated diesel engine. The Load increases the fuel consumption increases.

LOAD Vs TOTAL FUEL CONSUMPTION

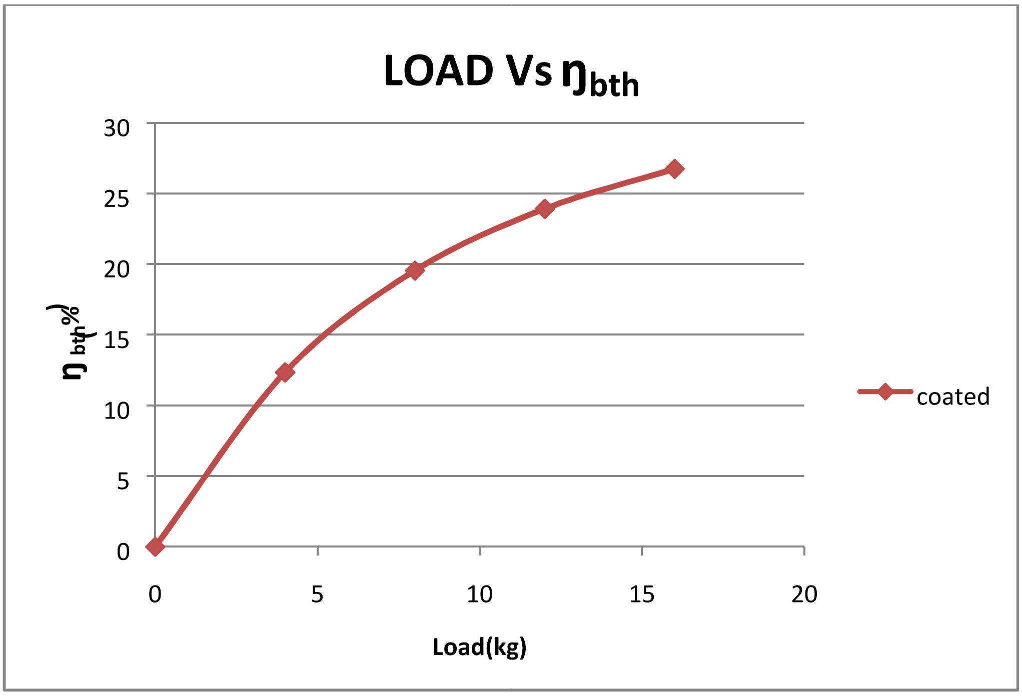

Fig 6.6: Load Vs ηbth of coated diesel engine.

The above fig 6.6 shows the relation between BP and brake thermal efficiency of coated diesel engine the BP increases break thermal efficiency increases.

BRAKE POWER Vs BRAKE THAERMAL EFFICIENCY

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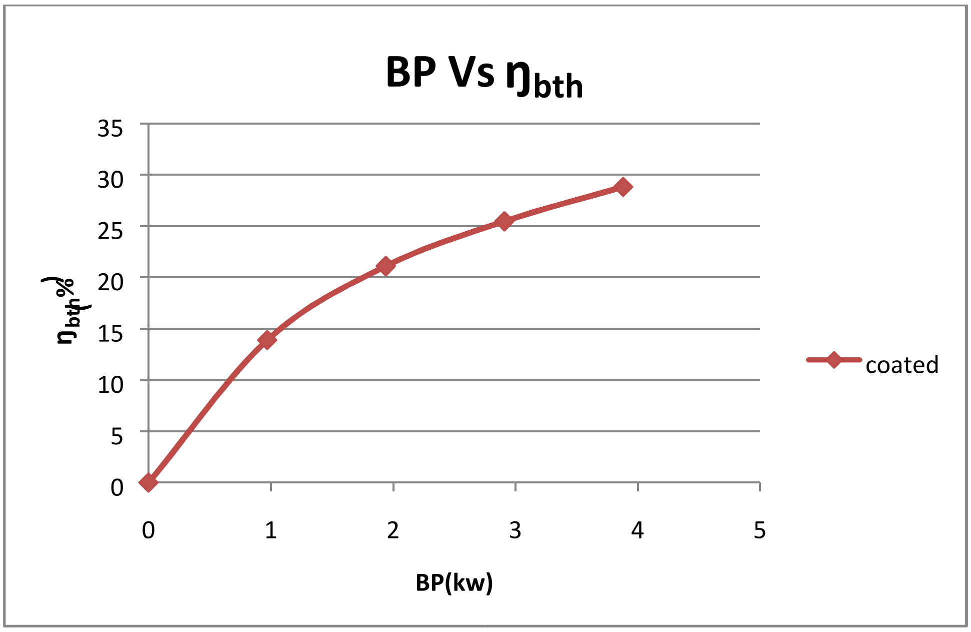

Fig 6.7: BP Vs ŋbth of coated diesel engine

The above fig 6.7 shows the relation between BP and brake thermal efficiency of uncoated diesel engine the BP increases break thermal efficiency increases.

BRAKE POWER Vs BRAKE SPECIFIC FUEL CONSUMPTION

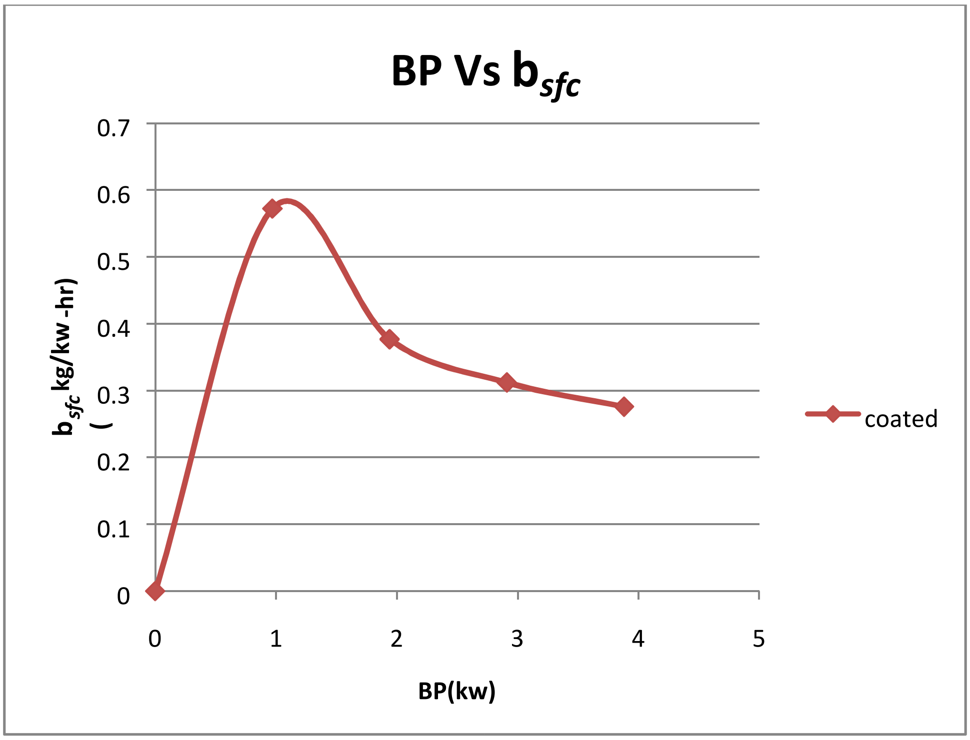

Fig 6.8: BP Vs b_{sfc} of coated diesel engine

The above fig 6.7 shows the relation of BP Vs Brake specific fuel consumption of coated diesel engine. The fuel consumption increases and decreases at higher load. **Performance Charts for uncoated and coated diesel engine**

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Performance charts are those which compare the performance parameters which are found on the engine for those produced diesels. These charts mainly drawn basing on the brake power Vs other parameters some of these charts are drawn between the following-

1. Brake Power Vs Brake Thermal Efficiency.
2. Brake Power Vs Total fuel consumption.
3. Brake Power Vs Mechanical Efficiency
4. Load Vs Brake Thermal Efficiency.
5. Load Vs Total fuel consumption.

Load vs total fuel consumption

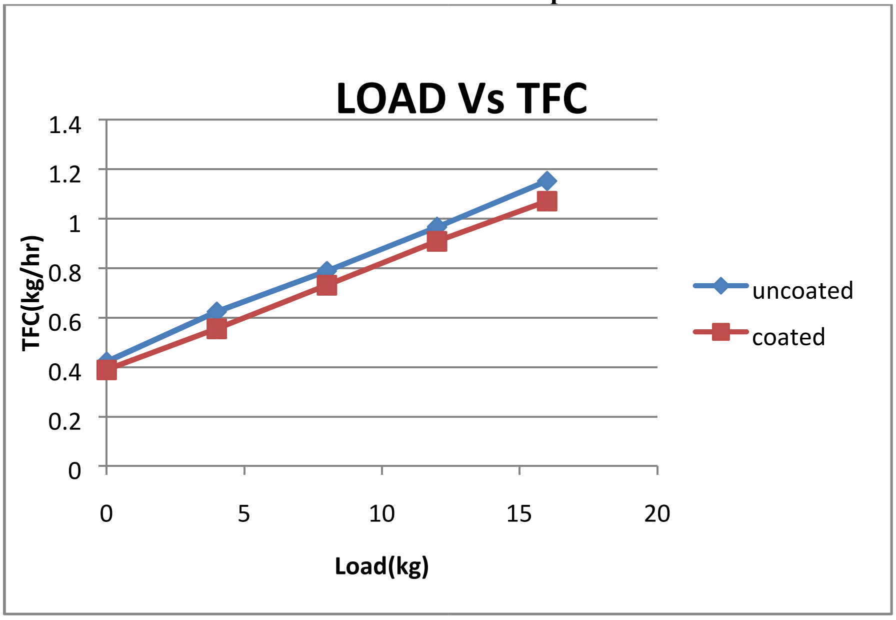

Fig 6.9: Load vs TFC

The above graph shows the variation of total fuel consumption of uncoated engine and YSZ coated piston crown and cylinder head engine. The total fuel consumption is reduced by 7.14% compared to uncoated engine complete combustion of fuel may reduce the fuel consumption.

Load vs Brake thermal efficiency

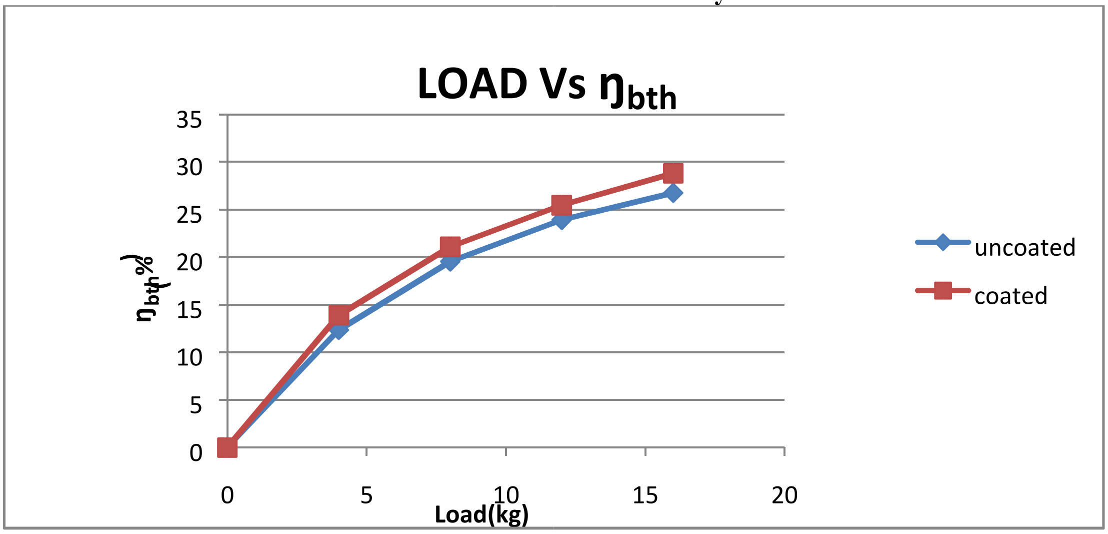

Fig 6.10: Load vs BTHE

The variation of break thermal efficiency with load of YSZ coated engine and uncoated engine is shown in the graph 2.2 it is significant that the modified engine has higher efficiency than the base line engine. The reduced

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thermal loss is the reason for the improvement of the break thermal efficiency. The maximum efficiency obtained for the engine operating on YSZ coated and uncoated engine are 28% and 26%.

Brake power vs total fuel consumption

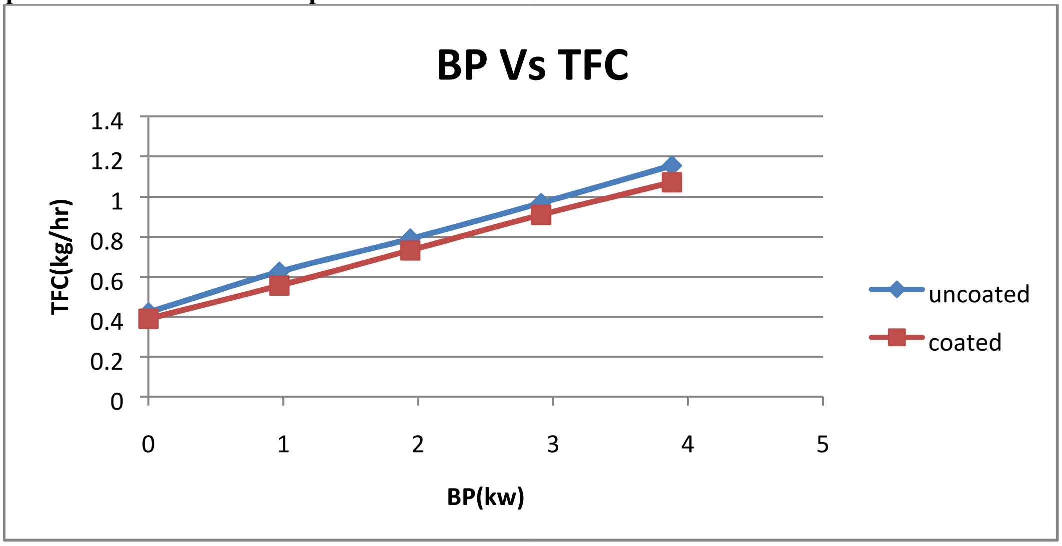

Fig 6.11: BP Vs TFC

The above graph the shows the variation of total fuel consumption of uncoated engine and YSZ coated piston crown and cylinder head diesel engine. The total fuel consumption is reduced by 7.14% compared to uncoated engine.

Brake power Vs Brake thermal efficiency

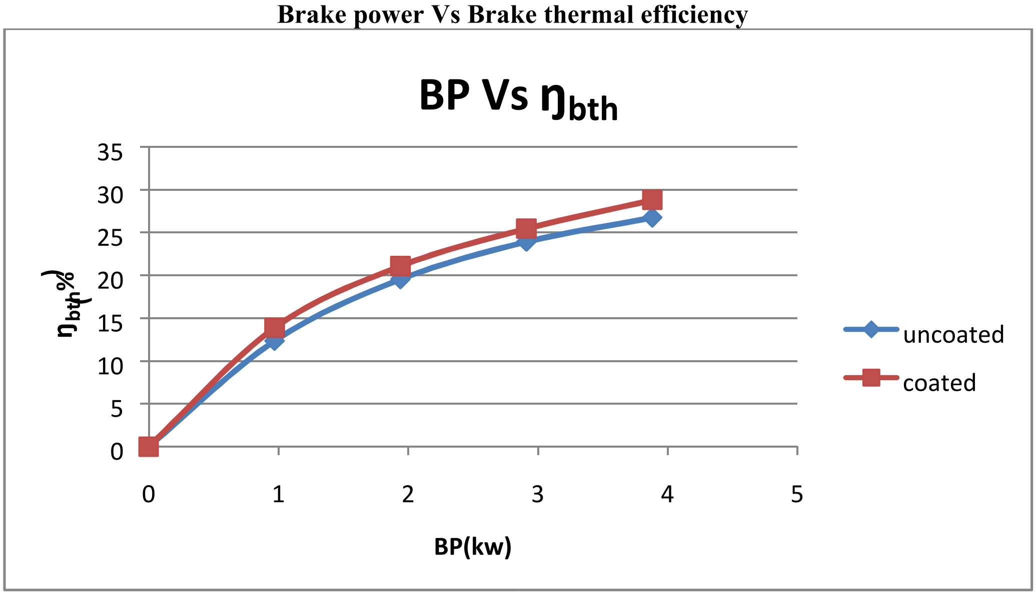

Fig 6.12: BP Vs η_{bth}

The variation of break thermal efficiency with Brake power of YSZ coated engine and uncoated engine is shown in the graph 2.2 it is significant that the modified engine has higher efficiency than the base line engine. The reduced heat loss is the reason for the improvement of the break thermal efficiency. The maximum efficiency obtained for the engine operating on YSZ coated and uncoated engine are 28% and 26%.

CONCLUSIONS

The following conclusions can be drawn from the experimental results:

1. Coated diesel engines use 7.1% less fuel overall than uncoated diesel engines to achieve the same results. The reduction is due to the full combustion of the fuel.

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2. The results demonstrate an improvement in brake thermal efficiency following coating, with the improvement being attributed to decreased heat loss. The engine running on YSZ coated and uncoated engines achieves maximum efficiency of 28% and 26%, respectively.

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