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# Performance and Exhaust Emission Studies of an Adiabatic Engine with Optimum Cooling

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**Abstract**

An attempt has been made to study the performance and exhaust emission studies of a diesel engine by insulating the combustion chamber using ceramic material attaining an adiabatic condition. The cycle average gas temperature and metal surface temperature are higher in adiabatic engine. Many researchers have carried out a large number of studies on LHRE (Low Heat Rejection Engine) concept.[7] In the case of LHR engines almost all theoretical studies predict improved performance but many experimental studies show different picture. An experimental investigation of the performance of a ceramic coated engine was carried out and the results were compared to the base engine. Piston top surface, cylinder head and liners of a multi cylinder vertical water cooled self-governed diesel engine were fully coated with Partially Stabilized Zirconia (PSZ).The engine was run at an optimum water cooling condition with constant speed and variable load condition as observed in most urban driving conditions. During the experiment, various measurements like fuel flow, exhaust temperature, exhaust emission were carried out. The results indicate improved fuel economy and reduced pollution levels for the Thermal Barrier Coated (TBC) engine.



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*Keywords:* TBC diesel engine; Partially Stabilized Zirconia; LHRE engine; Thermal efficiency; Mechanical efficiency; Volumetric efficiency; Exhaust emission; Smoke density; Heat balance sheet.

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## 1. Introduction of TBC

Heat engines are designed and manufactured considering various factors such as durability, performance and efficiency with the objective of minimum life cycle cost. The performance of internal combustion engines needs to be improved depending on some technological requirements and rapid increase in the fuel expenses. On the other hand, the improvements in the engine materials are forced by using alternate fuels and environmental requirements. Therefore, the choices of engine material become very important. Metallic coatings were introduced to sustain high temperatures. The trend for the most efficient internal combustion is to exploit more advances in material and cooling technology by going to engine operating cycles which employ a large fraction of the maximum temperature capability for the entire operating cycle.[1,2] Thermal Barrier Coatings (TBC) performs the important function of insulating components of I.C. Engine, gas turbine and aero engine operating at elevated temperatures. Thermal barrier coatings (TBC) are layer systems deposited on thermally high loaded metallic components, as for instance in engine. TBC's are characterized by their low thermal conductivity. The coating when exposed to heat bears a large temperature gradient. The most commonly used TBC material is Yttrium Stabilized Zirconia (YSZ), which exhibits resistance to thermal shock and thermal fatigue up to 1150$^{o}$C. YSZ is generally deposited by plasma spraying and electron beam physical vapour deposition (EBPVD) processes. It can also be deposited by high velocity oxy fuel (HVOF) spraying for applications as wear prevention, where the wear resistant properties of this material can also be used. The use of the TBC raises the process temperature and thus increases the efficiency.[5,6]

Thin ceramic coating of 500 microns was applied on the top surface of the pistons with bowls, head of the cylinder, liners and valves of the diesel engine. To avoid overheating & under cooling of engine, optimum cooling water mass flow rate was obtain which gives maximum overall efficiency of the engine for different load condition of engine.[4,10]The aim was to investigate the performance of diesel engine under said thermal barrier coated components with optimum cooling water conditions ,effect on heat balance sheet, exhaust emissions and smoke density.[8,9]

The thermal barrier coating of zirconium Zr $O_2$ is selected because of its better wear resistance , low thermal conductivity , high thermal shock resistance & high melting point (about 2800$^{0}$C). The bond coat of nickel aluminium powder provides good corrosion proactive bond coats and by forming a protective oxide scale. Use of composite ceramic powder coating results into excellent flow ability, chemical homogeneity, structural stability, uniform particle melting etc. Use of plasma spray coating in TBC results into production of high temperature, resistance to thermal cycling stresses and strains.[3] Plasma spray process parameters for zirconium oxide Zr $O_2$ are:

| | | |
|---|---|---|
| 1. | Material specification | : -22 ± 5 Microns |
| 2. | Stabilizer agents Bond coat | : NiAl (Ni-95%, Al-5%) |
| 3. | Coating thickness | : 500 Microns |
| 4. | Power required | : 32.5 KW. |
| 5. | Voltage | : 65 V |
| 6. | D. C. Current | : 500Amp. |
| 7. | Plasma generating gas | : Argon (Ar) |
| 8. | Powder deposition distance | : 70 to 90 mm. |
| 9. | Powder feed rate | : 20-25 Grams / min. |
| 10. | Pressures | : 120 Psi. |
| 11. | Plasma process type | : D. C. Arc |

## 2. Experimental set up

The experimental work was carried out on twin cylinder four stroke vertical water cooled diesel engine with a bore of 80 mm and stroke 110 mm. The engine is rated for 7.35 (10 HP) and 1500 RPM with a centrifugal governor to control the speed. The engine was connected with a electric dynamometer was used to measure the power output. The engine is instrumented to measure the parameters like fuel consumption, load ,speed of engine, cooling water temperature, inlet air and exhaust gas temperature etc. The engine test was carried out with constant