PERFORMANCE AND EMISSION CHARECTERISATICS OF MAGNESIA STABILIZED ZIRCONIA (Mg-PSZ) COATED DI DIESEL ENGINE RUNNING ON NELLI OIL

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Abstract

Demand for Fossil fuels has been increasing tremendously which cause environmental threat. For this reason a numerous studies are ongoing for renewable sources of energy worldwide. This paper investigates the effect of using TBC to diminish emissions from engine exhaust specifically nitrogen oxide and to augment the performance of the engine. Engine Components were coated with Mg-PSZ of which 150µm thinness of Zro_2-24Mgo over a 50µm thickness of NiCrAlY bond. The input parameters considered for this study includes engine speed, compression ratio, stroke length and Neli oil. The output parameters such as thermal efficiency, Brake power, Brake Specific Fuel Consumption, Volumetric Efficiency and Emissions of NOx, CO, HC were studied in a thermal barrier coated engine running with Neli oil and diesel fuel blend. From this experiment it is observed that there is a significant improvement in the results of engine performance and emission characteristics.

Key Words: *Mg-PSZ, Plasma Spray Coating, Nelli Seed Oil, Diesel Engine, Emissions.*

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1. INTRODUCTION

Diesel engine falls in the category of internal combustion engine, which is also known as compression ignition engine, where the fuel is ignited alone by the high temperature created by compression of air. The mixture of air-fuel in compression ignition engine is heterogeneous in nature. Due to this heterogeneous combustion which is taking place inside the cylinder causes enormous release of emissions such as Oxides of nitrogen, Carbon Monoxide, Hydro Carbons which in turn causes environmental pollution and health issues. The performance and emission characteristics of diesel engines depend on several factors such as compression ratio, Injection pressure, Combustion chamber, Fuel spray pattern etc. Because of drastic depletion of fossil fuels intense research is going for the search Alternative Fuels. Hence efforts are being made to improve the performance and reduce the emissions from compression ignition engine by selecting suitable alternative fuel, implementing different techniques such as coating the engine etc.,

The heat transfer from the engine occurs through the combustion chamber components such as piston, cylinder head, inlet and outlet valves. With low thermal conductivity ceramic coatings on the combustion chamber surfaces, inlet and out let valves keep the heat in the chamber and hence increase the temperature[1].

With the help of ceramic based Thermal barrier coatings (TBC) , improved combustion, reduced emissions and causes higher thermal efficiencies of the engine is achieved . Kamo and seker[2] developed a ceramic based thermal barrier coated engine for passenger cars and reported an improved performance in the maximum extent of 12%. Samria[3] used adiabatic material on the piston and reported a 19% reduction in heat loss through the piston.

Literature reviews results show that insulation of the engine combustion chamber reduces heat rejection, improves availability of energy which causes increase in thermal efficiency of the engine. But the paper by MohamedMusthafa[4], Mittal N, Athony RL M[5] reported that they observed no considerable improvement in Thermal efficiency. Different composites like SiCa, silicon nitride, Al, MgSiO2 and other ceramic materials were used in Low heat rejection engine concept[6].

Vegetable oils used in diesel engines were studied by Nazar et al. (2004). It is studied from the experiments conducted and checked the compatibility of coconut oil and karanj as alternative fuel in diesel engine, and results showed that, for shorter period of tests coconut oil and karanj can be directly used as alternative fuel in diesel engines without any modifications. With this alternative fuel nearly same power output was noticed with slightly reduced thermal efficiency when compared with diesel. HC and CO emissions are recorded high for vegetable oils under normal operating conditions [7].

Investigations were carried out on a variety of alternative fuels in compression ignition engines. With the advantages of alternative fuels in compression ignition engines produce nearly same power output but reduction in thermal efficiency and increased in exhaust emissions. The

particulate emissions from this alternative fuels are higher than that of diesel fuel with lower value of NOx emissions. Raja et al., 2003; Jeffrey and Nancy,2009;Agnes et al., 2007 [8]

Table 1. Properties of Nelli Oil

Properties	Diesel	Nelli Oil
Kinematic viscosity at 40 ^{0}C (cSt)	0.715	43.53
Density at 15 ^{0}C (kg/m^3)	850	910
Flash point (^{0}C)	45	280
Calorific value (kJ/kg)	43000	39100
Sp.gravity	0.85	0.91

Table 2. Properties of Bond coat and Mg- PSZ

Material properties	**NiCrAlY**	**Mg-PSZ**
1.Thermal Conductivity (W/mK) @RT	3.88	1.2
2.Coefficient of thermal expansion (x10^{-6}K^{-1}) @RT	10.3	10
3.Density	6290	5600
4.Specific heat (J/Kg K) @RT	460	400
5.Modulus of elasticity (GPa)	64.5	350
6.Poissions Ratio	0.30	0.23

2. PLASMA SPRAY COATING

In thermal spray system, Plasma spray process is being versatile and it is being used for ceramics, carbides, metals and Non-Metals. Plasma spray coating is applied on base materials for wear, corrosion protection, improve and retrieve the properties of the material.

In Plasma spray system, an electric arc created between two fixed electrodes. Process gas like helium, hydrogen, nitrogen and argon flows through the cathode and anode which is shaped as a converging nozzle. It is initiated with a high voltage discharge which causes localized ionization.

Powder (Sulzer Metco) form of coating material is fed into the plasma flame most commonly through an external powder port mounted near the anode nozzle exit. This power is readily heated and accelerated to deposit on work piece. Compressed air is used as the cooling gas during spraying on the desired component.

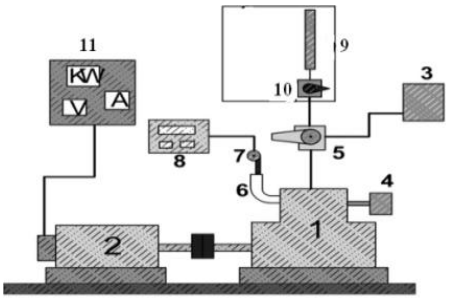
Table 3. Plasma spraying Parameters

Sl.No	**Parameters**	**Value**
1.	Spray gun	5 MB
2.	Nozzle	GH
3.	Current (A)	455
4.	Voltage (V)	55-60
5.	Powder feed (g/min)	35-40
6.	Spray distance	85-120 ± 10 % mm
7.	Particle velocity	Up to 450
8	Arc Temperature (˚C)	15000
9.	Particle size (μm)	65-80
10	Inert gas flow rate	
	a.)Helium (l/min)	120-200 ± 5%
	b.) Nitrogen (l/min)	120 ± 5%

4. TEST ENGINE

The set up of this experiment consists of engine, Dynamo meter, top load system, fuel tank, exhaust gas measuring digital device and manometer. Make of the engine is Kissan group Company. Tests were conducted on four stroke, single cylinder, water cooled, DI diesel engine. Method of loading used is Electrical loading. Engine is stabilized and achieved steady state. Readings such as time taken for 10cc fuel consumption, HC, CO, NOx levels and exhaust gas temperature were taken.

Below figure shows the layout of Experimental set up of NEWKISSAN DIESEL ENGINE



1.NEWKISSAN ENGINE 2.ELECTRICAL DYNAMOMETER 3. DIESEL TANK 4. AIR FILTER 5.THREE WAY VALVE 6. EXHAUST PIPE 7. PROBE 8. EXHAUST GAS ALYSER 9. BURETTE 10. VALVE 11. CONTROL PANEL

Figure1: Schematic view of Experimental set-up

Figure 2: piston crown and cylinder head coated with Magnesia Stabilized Zirconia (Mg-PSZ)

Figure3: Nelli seeds and Nelli Fruit

Specifications of Engine

Engine type	Vertical, Four Stroke diesel engine
Bore Diameter	85 mm
Stroke Length	110 mm
Brake Power	3.68
Compression Ratio	16.5:1
Speed	1500 rpm
Injection Type	Direct Injection
Cooling	Water
Engine Power	5 bhp
No. Of Cylinders	1
Injection Pressure	180 bar

UNCE- Un Coated Engine

CEWNO- Coated Engine With Nelli Oil

6. RESULTS AND DISCUSSIONS

Trails were conducted on four stroke, single cylinder, and DI Diesel engine which are running at constant speed. Experiments were carried out on both conventional engine (without Thermal Barrier Coating) and engine coated with Thermal Barrier Coating running with Nelli oil Diesel fuel blend.

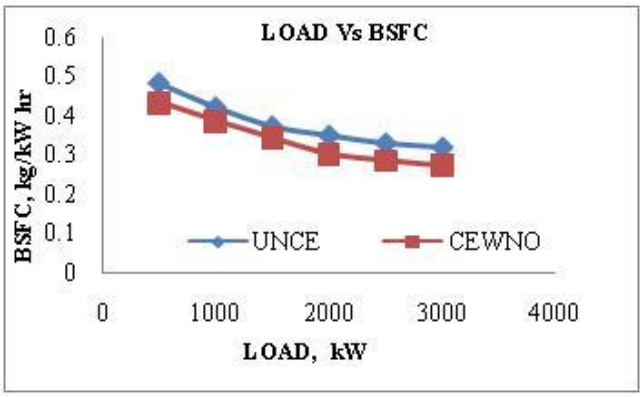


Figure 4: BSFC at various loads

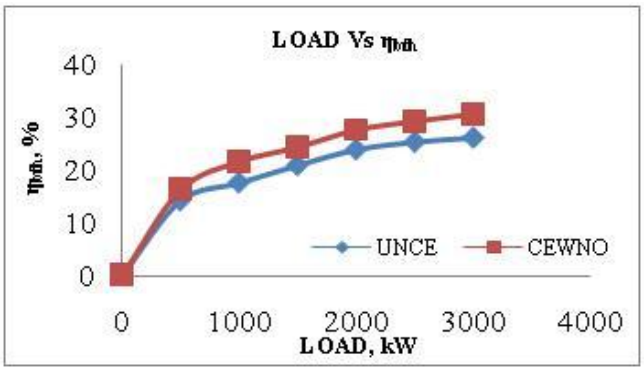


Figure 5: Brake Thermal Efficiency at various loads

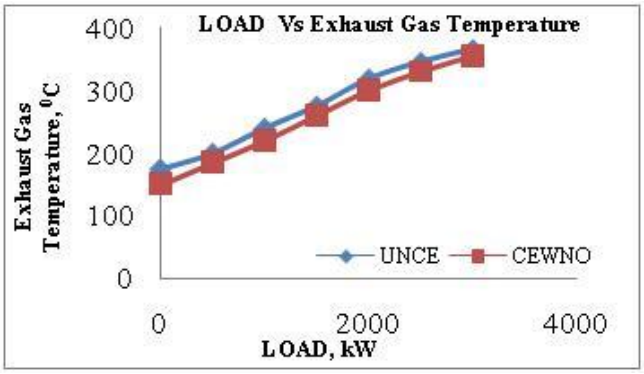


Figure 6: Exhaust Gas Temperatures at various loads

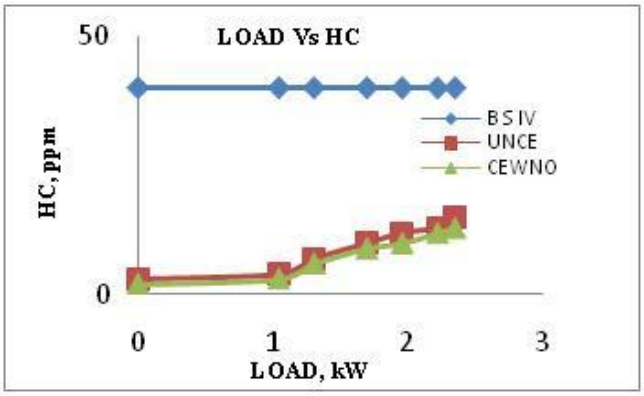


Figure 7: Hydro carbon emissions at various loads

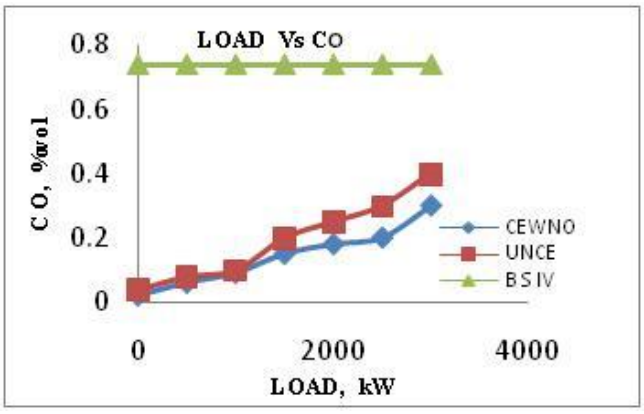


Figure 8: CO emissions at various loads

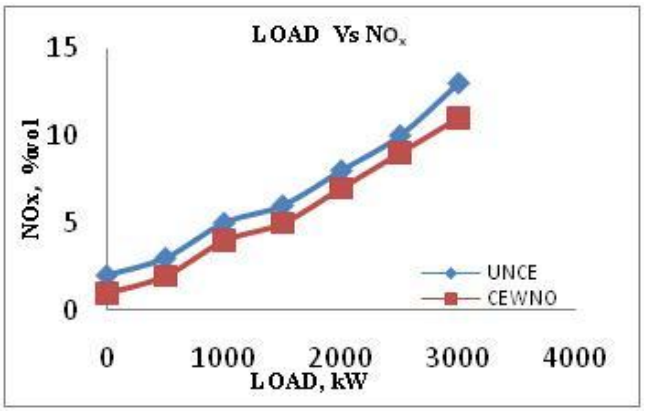


Figure 9: Oxides of Nitrogen emissions at various loads

Figure 4 to Figure 9 shows the results acquired from the experiments conducted on the engine running at constant speed. The performance and emission characteristics of Mg-PSZ coated engine components such as valves; piston crown and cylinder head were investigated and compared with non-coated Engine.

Figure4 reviles the contrast of Brake specific fuel consumption of non-coated engine and Mg-PSZ coated engine running with Nelli oil diesel fuel blend. It is observed that BSFC value is decreased by 15.35% for Mg-PSZ coated engine running with Nelli oil as compared to conventional engine at full engine load. Since the engine components such as piston crown, valves and cylinder head is coated with Mg-PSZ the combustion chamber achieves higher surface temperature and the diesel fuel blend starts burning efficiently causes the BSFC values of coated engine are lower than those of conventional engine.

Figure5 reviles the contrast of brake thermal efficiency of non-coated engine and Mg-PSZ coated engine running with Nelli oil diesel fuel blend. It is clear from the graph that Brake thermal efficiency is minimum for non-coated Engine and maximum for Mg-PSZ Coated Engine running with Nelli oil. The break thermal efficiency is increased by 10.25% from coated engine running with Nelli oil at maximum load when compared to conventional engine. Mg-PSZ coating provides less heat rejection from combustion chamber through thermally insulated components such as piston crown, valves and cylinder head increases available energy cause complete combustion of diesel fuel blend. Hence thermal efficiency is slightly higher when compared to the non-coated engine.

Figure6 reviles the contrast of exhaust gas temperatures with respect to Load for non-coated engine and coated engine running with Nelli oil. It is observed that a marginally lower exhaust gas temperature in the case of coated Engine running with Nelli oil compared to non-coated Engine is because of retrieved higher surface temperatures of combustion chamber. It is observed that coated Engine running with Nelli oil has the lowest exhaust gas temperature which is 1.2% compared to non-coated Engine.

Figure7 reviles the contrast of hydrocarbon emission for different loads for non-coated and coated engine running with Nelli oil. Because of incomplete combustion Unburnt hydrocarbon emissions occurs it is clear from the graph that hydrocarbon emissions are decreased because of Mg-PSZ, which results in complete combustion of fuel. From the results hydrocarbon emissions are lowered of 10% for coated piston, valves and cylinder head compared to non-coated Engine.

Figure8 reviles the contrast of carbon monoxide with respect to Load is presented in graph. The results of carbon monoxide emissions for non-coated Engine, coated Engine are 0.4% and 0.3% volume respectively. The Carbon monoxide emissions are lower of 23% for coated Engine running with Nelli oil compared with non-coated Engine.

Figure9 reviles the contrast of Oxides of Nitrogen Emissions in exhaust with respect to Load for non-coated engine and coated engine running with Nelli oil. From the results emissions are lowered of 15.38% for coated Engine running with Nelli oil compared to non-coated engine. From the results it is observed that Nitrogen oxide emissions decrease due to Mg-PSZ Thermal Barrier Coating (TBC) in the cylinder causes local peak temperature and the availability of oxygen reduces NOx Emissions from the Exhaust.

8. CONCLUSIONS

The following are the conclusions based on the investigation results obtained while operating single cylinder water cooled diesel engine operated with Engine components coated with Mg-PSZ and non-coated engine running with Nelli oil (B50).

Tralatitious diesel engine is transformed into Mg-PSZ coated diesel engine to determine the performance and emission characteristics of the engine running with Nelli seed oil (B50). The following conclusions are drawn from the experimental results. From the results it is clear that increase in brake thermal efficiency by 10.25% for Mg-PSZ coated engine. There is a decrease in specific fuel consumption by 15.35% for Mg-PSZ coated compared to normal engine. Hydrocarbon emissions are lowered of 10% for coated piston and cylinder head compared to normal Engine. Carbon monoxide emissions are lower of 23% for coated Engine compared with conventional Engine.

NOx emissions are lowered by 15.38% for Engine coated with Mg-PSZ and running with Nelli oil diesel fuel blend compared to non-coated engine. Hence, coated engine running with Nelli oil shows better performance and emission characteristics compared to non-coated engine.

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