International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

PERFORMANCE AND EMISSION EVALUATON OF THERMAL BARRIER (NICKEL-CHROMIUM) COATED DIESEL ENGINE USING SOAP NUT BIO-DIESEL BLENDS

Dr. K. Kalyani Radha[1] Dr. B. Omprakash[2] ,

1.Associate Professor, *Dept. of Mech Engg, JNTUACEA, Ananthapuramu, A.P, INDIA.*

2. Associate Professor, *Dept. of Mech Engg, JNTUACEA Ananthapuramu, A.P, INDIA*

Abstract: **Efforts are being made throughout the world to reduce consumption of liquid petroleum fuels. Biodiesel is recentlygaining much prominence in a substitute for petroleum based dieselmainly due to environmental considerations and depletion of vitalresources like petroleum and coal.The vegetable oils are the promising alternative among the different diesel fuel alternatives. However high viscosity, poor volatility and cold flow characteristics of vegetable oils can cause some problems such as injections choking, severe engine deposits filter gumming, piston ring sticking and thickening of lubricant oils from long term use in Diesel engines. Such problems can be eliminated by Thermal barrier coating (insulation) on engine parts such as cylinder head, piston crown, valves etc.Thedieselengine rejects 30% energy to coolant and 30%energy tothe exhaust leaving only about 30% energy is the useful work. If the heat rejection could be reduced then the thermal efficiency energywould be improved. Therefore using bio-diesel in the thermal barrier coating is the only solution for these problems.**

Tests are conducted on conventional engine and Ni-Cr coated engine with the diesel and soap nut bio-diesel blend of 10%.Nickel-Chromium (Ni-Cr) coating of thickness of 0.2 mm on the piston crowndone by plasma spray method.Experimental results showed that the brake thermal efficiency was increased with simultaneous decrease in fuel consumption (BSFC). Further exhaust emission parameters such as CO, HC,CO_2 and NO_X were also decreased.

Keywords: Soap nut oil, Nickel-Chromium(Ni-Cr), Plasma spray method, Bio-diesel, Thermal barrier coating.

I.INTRODUCTION

Depleting petroleum reserves and increasing cost of the petroleum products demands in the intensive search of new alternative fuels. Bio-dieselsare proved to be very substitute to petro diesels. Bio-diesels derived from vegetable oils present a very promising alternative to diesel fuel since bio

Diesels have numerous advantages compared to fossil fuels as they are renewable, biodegradable; provide energy security and foreign exchange savings besides addressing environmental concerns and socio-economic issues. Experiments were carried out withjatropha[1], rapeseedoil [2], karanja[3], orange oil[4] bio-diesel on direct injection Diesel engine and it was reported that performance was compatible with pure diesel operation on conventional engine

The quest for developing energy efficient internal combustion engines has been going on from past several decades. In recent times, research is focused on reducing the energy lost to exhaust gases, cooling systems, all and head of combustion chamber. One of the trends is to improve performance of the heat engines by engine adiabatization. The method to adibatize an engine is to cover the surfaces of the combustion chamber with a thermal barrier coating. The thermal insulation provided by coating leads to energy efficient engines.Kamo and Bryzik [5] used thermal barrier coating such as silicon nitride for insulating different surfaces of the combustion chamber and found an improvement of 7 % in engine performance. ImdatTaymaz [6] coated the head, combustion chamber surfaces, valves and piston crown faces with $CaZrO_3$ and $MgZrO_3$, Observed that at medium load effective efficiency improved by 2 %. However the authors have not clearly demarcated the influence of speed and the effect of thermal barrier coatings on enhancing of thermal efficiency of the engine. Abdulla Uzun and Ismet cevik [7] showed that with thermal barrier coatings on diesel engine, the thermal efficiency increases by 10 % and fuel consumption showed a 2 % decrease. I.Taymaz and K.Cakir [8] have shown that the thermal barrier coatings on the combustion chamber of a diesel engine prevent the excessive heat loss during the combustion. ImdatTaymaz [9] has shown in a LHR engine, High temperature on the combustion chamber wall surface due to insulation cause a drop in volumetric efficiency. Ekrem Buyukkaya, Tahsin Engine and Muhammet cerit [10] have developed a low heat rejection engine and showed that 1-8 %reduction in brake specific fuel consumption can be achieved.

The main aim of this study is to evaluate the performance and emission evaluation of Nickel-Chromium coated diesel engine fuelled with soap nut bio-diesel blends from NO load to FULL load conditions.

II .METHODOLOGY

Soap nut is also known as *Sapindusmukorossi*, commonly growing trees in India. The oil content from soap nut is in range of 50-55% of seed weight which is identified as non-edible oil which otherwise is a waste material. Soap nut seeds were collected and the kernels were separated according to their condition. Then the damaged seeds are removed and seeds in good conditions cleaned, de-shelled and dried at temperature 30°C for 1-3 hours. The dried seeds were crushed to make powder. The oversized particles were crushed again and the undersized particles were taken to extract the oil.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Fig1 .soap nut seeds and kernels

A. Extraction of oil: Oil was extracted from crushed and powdered kernel in petroleum ether taken by the weight ratio of 1:3 in a 2L conical flask by stirring magnetically at room temperature for 4 hours. The solvent was removed at 15^{0}C by a rotary vacuum evaporator toyield the crude oil.In general n-hexane is taken as solvent in this process. This process was repeated 2-3 times with the seed cake using fresh solvent each time in order to extract most of the oil which was further dried using vacuum pump.

*B. production of bio-diesel***:** It is the reaction of a crude oil with an alcohol to form esters and glycerol. 20 g of soap nut seed oil was weighed and poured into a 250 ml round bottom flask and was made to react with the mixture of catalyst potassium hydroxide (KOH) and methanol. The flask was kept in a magnetic stirrer for 4–5 hours at a temperature of 60 ^{0}C. The mixture was allowed to settle in two layers, the lower layer is a methanol–glycerol mixture and the top layer is a biodiesel layer. The two layers were separated with the help of a separating funnel. The bottom layer was separated and distilled to recover the methanol. The top layer was washed with water to remove the traces of methanol and glycerol and the biodiesel is dried in the hot air oven and stored.

C. Plasma spray coating process:

Procedure:

An electric arc is formed between a cathode and the concentric nozzle of the spray gun A mixture of gases with a high flow rate along the electrode is ionised by the arc, and forms plasma. This plasma stream is pushed out of the nozzle, where the powder of the Nickel-Chromium coating material is injectedinto the plasma jet. The heat and velocity of the plasma jet rapidly melts and accelerates the particles so that they are propelled to form a coating of thickness 0.2mm on to the substrate.

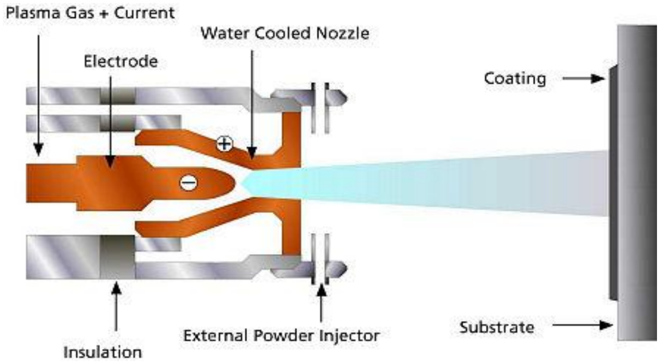


Fig3.Schematic diagram of the plasma spraying process

Fig4.Before coating after coating

III.EXPERIMENTAL WORK

Experiment is carried out in diesel engine with the following engine specifications are shown in table 1

Engine specifications:

Table1
ENGINE SPECIFICATIONS

Model	AV1
Make	KIRLOSKAR
Type	Single cylinder, four stroke, water cooled
Bore	80mm
Stroke	110mm
Speed	1500rpm
Rated power	5hp

Procedure:

Initially experiment is done on conventional engine fuelled with soap nut blends of 10% and diesel from no load to full load and the following readings are noted,

a. Engine speed
b. Time taken for 5cc of fuel consumption.
c. Voltmeter and ammeter readings.
d. Temperatures at different locations.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

e. exhaust emissions such as CO_2,CO,HC and NOx by using exhaust gas analyzer.

Then the engine is modified with the Nickel-Chromium coated piston of 0.2 mm thickness and the same procedure was repeated to evaluate the performance and emissions of coated engine.

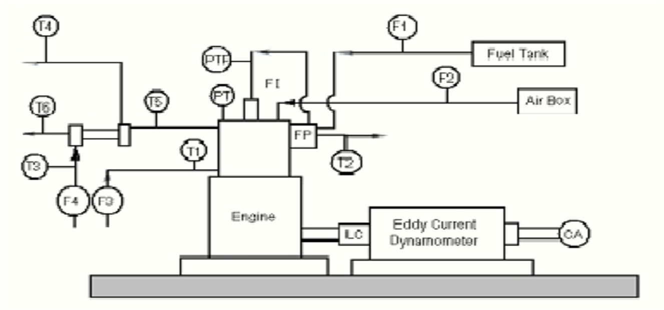


Fig5.Engine setup
PT: Combustion Chamber Pressure Sensor F
PTF: Fuel Injection Pressure Sensor
FI: Fuel Injector
FP: Fuel Pump
T1: Jacket Water Inlet Temperature
T2: Jacket Water Outlet Temperature
T3: Inlet Water Temperature at Calorimeter
T4: Outlet Water Temperature at Calorimeter
T5: Exhaust Gas Temperature before Calorimeter
T6: Exhaust Gas Temperature after Calorimeter
F1: Liquid fuel flow rate
F2: Air Flow Rate
F3: Jacket water flow rate
F4: Calorimeter water flow rate
LC: Load Cell
EGC: Exhaust Gas Calorimeter

Properties of soap nut fuel:

Table 2
PROPERTIES OF DIESEL AND SOAP NUT BIO-DIESEEL

PROPERTY	SN-10	DIESEL
Density(Kg/m^3)	856	835
Calorific value(KJ/Kg)	41762	43000
Kinematic viscosity*10^{-6}(m^2/s)	4.2	2.85
Flash point°C	102	70
Fire point°C	106	74

IV.RESULTS

1. Brake specific fuel consumption:

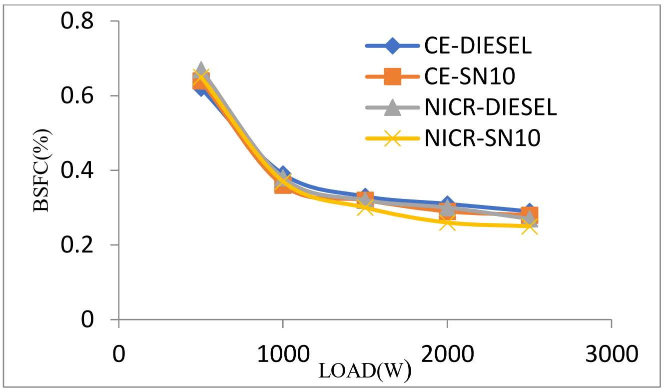


Fig6.Loadvs Brake specific fuel consumption

Fig 6 shows the variation of Brake specific fuel consumption with load of conventional engine and Ni-Cr coated engine. Lower BSFC is desirable because it is the measure of the engine's efficiency indirectly. BSFC and engine efficiency are inversely proportional.The BSFC is reduced about 8-11% for diesel and blend SN-10of Ni-Cr coated engine compared to conventional engine. Therefore it appears that the thermal barrier coatings have considerableinfluence at reduction in Brake specific fuel consumption It is mainly due to the higher temperature reached in the combustion chamber.

2. *Brake thermal efficiency*:

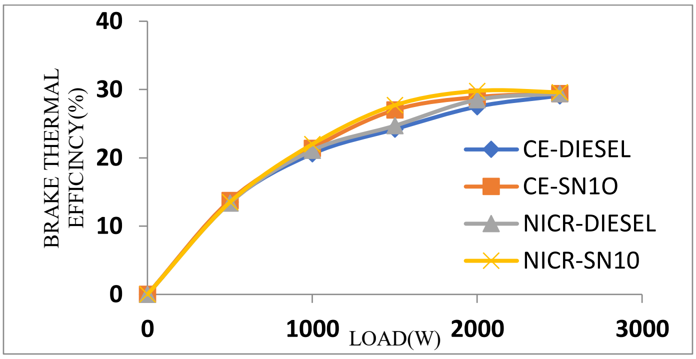


Fig7. Load vs Brake thermal efficiency

Fig 7 shows the variation of brake thermal efficiency with the load of conventional engine and Ni-Cr coated engine.The Brake thermal efficiency is found to increase by 1% for diesel and blend SN-10 at 80% load of Ni-Cr coated engine compared to conventional engine. It is due to the fact that the coating material (Ni-Cr) have low thermal conductivity, thereby providing a better insulation allowing a higher operating temperature and reducing cooling requirement which enhances the Brake thermal efficiency.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

3. Exhaust Gas Emissions of Carbon Monoxide:

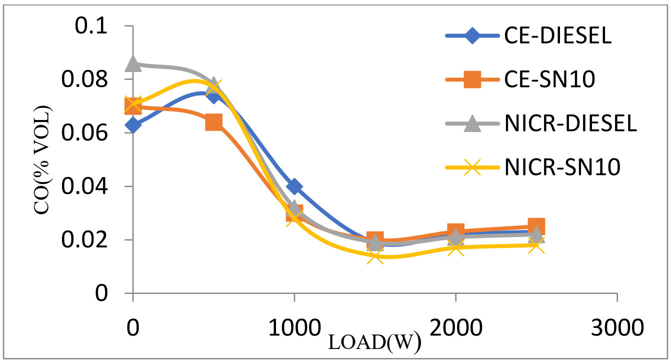


Fig8. Load vs CO emissions

Fig 8 shows the variation of carbon monoxide emissions with the load of conventional engine and Ni-Cr coated engine. The results showed that lower CO emissions in Ni-Cr coated engine when compared to conventional engine.This is due to complete combustion in coated engine and high oxygen content in bio-diesels. It is well known that better combustion leads to lower concentrations of CO at the exhaust [11].

4. Exhaust emissions of Hydro carbons:

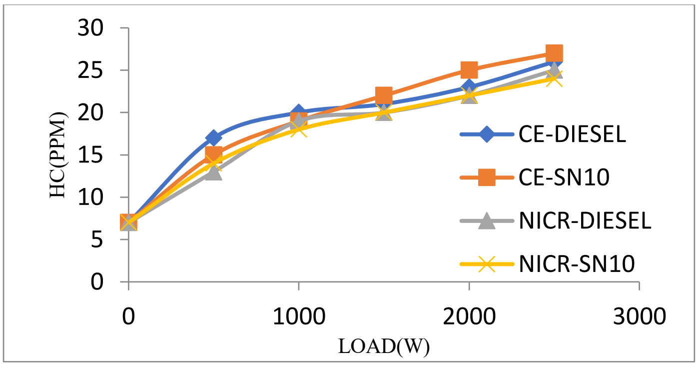


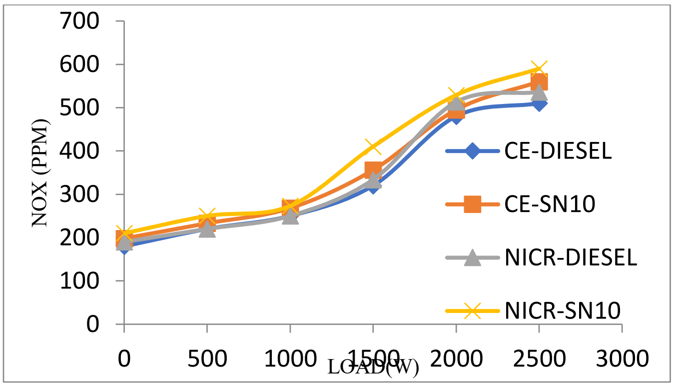
Fig10. Load vs NO_X emission

Fig 10 shows the comparison of hydrocarbon emission for different loads of conventional engine and coated engine [13]. From fig observed that NOx levels were lower in CE while they were higher in Ni-Cr coated engine at different operating conditions of the diesel and soap nut blends. This is due to increase of combustion temperatures with the faster combustion and improved heat release rates in Ni-Cr coated engine caused higher NOx levels [14]. The temperature and availability of oxygen are two favorable conditions to form Nox

Fig9. Load vs HC emissions

Fig 9shows the comparison of hydrocarbon emission for different loads of conventional engine and coated engine.Results showed that the UHBC emissions are reduced from no load to full load for diesel and blend SN-10 of coated engine compared to conventional engine. It is due to high after combustion temperature leads to complete combustion of fuel in the engine [12]. Combustion chambertemperature is inversely proportional to HC emission. So HC emissions are lower in coated engine as compared to conventional engine.

5. Exhaust Emissions of Nitrogen Oxides:



International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

6. Exhaust emissions of carbon dioxide:

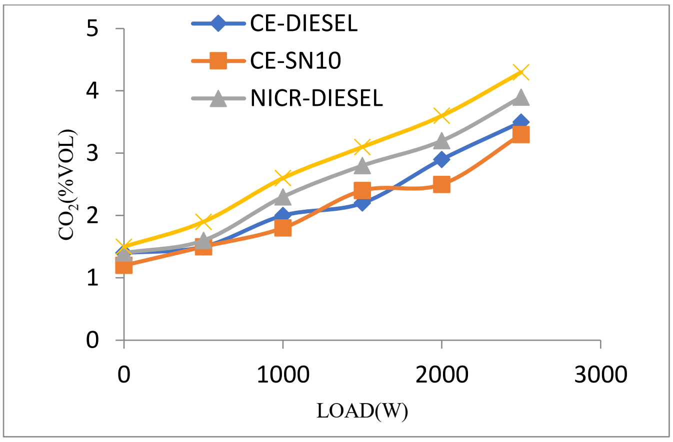


Fig11. Load vs CO_2 emissions

Fig 11 shows the comparison of hydrocarbon emission for different loads of conventional engine and coated engine.From fig it is observed that CO2 levels were lower in CE while they were higher in Ni-Cr coated engine. This is due to the good oxidation property of Ni-Cr coating leads to complete combustion of fuel increases the CO2 emissions in coated engine compared to conventional engine [15].

As the Nickel-Chromium is a low thermal conductivity material, it reduces the heat loss from the cylinder to the surroundings. Therefore the efficiencies are increased and the emissions are reduced because of various chemical reactions takes place inside the cylinder at high temperature.

The following results are obtained from the experimental investigations

1. The BSFC is reduced about 8-11% for diesel and blend SN-10 of Ni-Cr coated engine as compared to conventional engine.
2..The brake thermal efficiency is found to increase by 1% for diesel and blend SN-10 at 80% load of Ni-Cr coated engine as compared to conventional engine.

3. Lower CO emissions are produced in Ni-Cr coated engine when compared to conventional engine.
4. The coated engine has lower UHBC emissions compared to the normal engine.
5. The NO_Xemissions are higher in Ni-Cr coated engine as compared to conventional engine.

6. CO_2levels are lower in conventional engine while they were higher in Ni-Cr coated engine.

V.CONCLUSIONS

An experimental investigation of the effect of Nickel-Chromium coating on diesel engine fuelled with soap nut bio-diesel is conducted.
Based on experimental investigation it can be concluded that Soap nut oil can be suitable substitute for diesel with Nickel-Chromium coating enhances engine performance and reduce emissions.

VI. SCOPE OF FUTURE WORK

The present work can be extended by varying the thickness of the Nickel-Chromium coating on the piston crown and various alternative fuels also.

VIII.REFERENCES

[1] Reddy N, Ramesh A. “Parametric studies for improving of a jatropha oil-fuelled compression ignition engine”. *Renew energy 2006;31: 1994-2016.*

[2] He Y,Bao Yd ,”study on rapeseed oil as alternative fuel for a single-cylinder Diesel engine”. *Renew Energy2003;28:1447-53*

[3] Bajpai S, SahooPK, DAS LM. “Feasibility of blending of karanja vegetable oil in petro-diesel and utilization in a direct ignition diesel engine”.Fuel20009; 88:705-11.

[4] Purusothaman K, NagarajanG. Performance, emission and combustion characteristics of a compression ignition engine operating on neat orange oil.

[5] R.Kamo, W.Bryzik, -“Advanced adiabatic diesel engine for passenger cars", *SAE paper -840434(1984).*

[6] Imdat Taymaz, “The effect of thermal barrier coatings on diesel engine performance- Surface and Coating technology”. *201(2007) pp5249-5252.*

[7] Abdullah uzun, Ismet cevik, Mustafa akil, -“effect of thermal barrier coating on a turbocharged dies

[8] el engine Performance Surface and Coating technology”. *116-119(1999) pp505-507.I.T*aymaz, K.Cakir, A.Mimaroglu, -“Experimental study of effective efficiency in a ceramic coated diesel engine, Surface and Coating Technology”. 200(2005)1182-1185.

[9] Imdat Taymaz, “An experimental study of energy balance in low heat rejection diesel engine -Elsevier-Energy”*, volume31, issue 2-3,Feb-Mar-2006 pp-364-371.*

[10] ErkremBujukkaya, Tahsin Engine, Muhammad Cerit- “Effect of thermal barrier coatings on gas emission and performance of a LHR engine with different injection timings nd valve adjustments”., Energy conversion and management.

[11] Hameed, R., Palanivel, R., Kotla, P., Padma, L., & Jeyanthi, S. (2025, August). Blockchain-Integrated Reputation Evaluation Framework for Peer Review. In 2025 Third International Conference on Networks, Multimedia and Information Technology (NMITCON) (pp. 1-5). IEEE.

[12] Kotla, P. (2022). Accelerating Shared Services with UiPath: Lessons from Early Automation Centres of Excellence (CoEs). Available at SSRN 5379367.

[13] Kotla, P. (2023). Combining Document Understanding and Action Center in UiPath for Human-In-The-Loop Claims Processing.

[14] Kotla, P. (2023). Adaptive Learning in UiPath: Enhancing RPA for Continuous Improvement and Scalability Author Name: Praneetha Kotla Role: Lead Robotics Process Automation Developer. Available at SSRN 5315673.

[15] Kotla, P. (2024). Task Mining as a Catalyst for Automation: Realizing Process Improvement with Uipath in Healthcare Scheduling.