EXPERIMENTAL INVESTIGATION ON DI DIESEL ENGINE WITH NICKEL-CHROMIUM COATED PISTON USING MAMEY SAPOTE BIODIESEL

Mr. A. Raj Kumar[1], Dr. G. Janardhana Raju [2], Dr. K. Hemachandra Reddy[3]

[1]*Associate Professor & Head Dept. of Mechanical Engg., Guru Nanak Institutions Technical Campus,*
[2] *Prof & Dean, School of Engineering, Nalla Narasimha Reddy Group of Institutions, Hyderabad.*
[3]*Professor, Department of Mechanical Engineering, J.N.T.U Ananthapur.*
[1]*alugo72@gmail.com*, [2]*gjraju_06@rediffmail.com*, [3]*konireddy@gmail.com.*

Abstract

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. The diesel engine rejects 30% energy to coolant and 30% energy to the exhaust leaving only about 30% energy is the useful work. If the heat rejection could be reduced then the thermal efficiency energy would be improved. Therefore using bio-diesel in the thermal barrier coating is the only solution for these problems. Here, tests are conducted on DI diesel engine and Ni-Cr coated engine with the diesel and MameySapote bio-diesel blend of 15%.Nickel-Chromium (Ni-Cr) coating of thickness of 0.2 mm on the piston crown done by plasma spray method. Experimental results showed that the main purpose of this study was achieved as the engine performance parameter such 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: *Mamey Sapote oil, Nickel-Chromium (Ni-Cr), Plasma spray method, Bio-diesel, Thermal barrier coating.*

1.0 INTRODUCTION

Depleting petroleum reserves and increasing cost of the petroleum products demands in the intensive search of new alternatives fuels. Bio-diesels are proved to be very substitute to petro diesels. Bio-diesels derived from vegetable oils present a very promising alternative to diesel fuel since biodiesels 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 with jatropha[1],rapeseed oil[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 CaZrO3 and MgZrO3, 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 Engin 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 Mamey Sapote bio-diesel blends. The results showed that enhance in brake thermal efficiency and emissions such as CO, HC, CO_2 and NO_X were reduced in coated engine compared to conventional engine.

Methodology:

Mamey Sapote is also known as *Sapodilla*, commonly growing trees in India. The oil content from Mamey Sapote is in range of 25-30% of seed weight which is identified as non-edible oil which otherwise is a waste material. Mamey Sapote 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^{o}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.

Fig 2.1: Mamey Sapote fruit, seeds with Kernal

Fig 2.2: Mamey Sapote biodiesel

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 150c by a rotary vacuum evaporator to yield 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.

Production of Bio-Diesel:

The non-edible oils having high FFA content, which is not suitable for normal transesterification process. If the FFA content of the oil is less than 2.5%, then one step transesterification process with a base catalyst should be used and if it exceeds 2.5%, two step transesterification process should be the choice. In this study as the FFA content of MSO was 3.26%, two step base catalyst transesterification method has been adopted. In the present analysis the following parameters are chosen for the production of biodiesel.

In a batch reactor Mamey Sapota oil of 100 gm was placed and heated it up to 60º C temperature The stirrer speed was maintained at 500 rpm for constant mixing. The methoxide solution was prepared by dissolving the exactly measured quantity of solid catalyst (KOH) in premeasured quantity of methanol. Once the oil reached the up to 60º C temperature, the prepared methoxide was slowly poured into the reactor. The completion of pouring instant was taken as the start of reaction. The condenser was installed on one of the four necks to capture and reuse any vaporized methanol. Upon reaching the predefined time of reaction, the reactor was taken out of the heating mantle and the products of the reaction were shifted to a 500 ml separating conical funnel. After 24 h of settling, the heavy glycerol layer settled at the bottom of the funnel was removed through a drainage valve. The remaining crude biodiesel produced from MSO was gently washed with distilled water at 40 ºC in order to remove the un reacted methanol, catalysts and impurities. The percentage yield of biodiesel has been calculated using the formula

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 injected into 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.

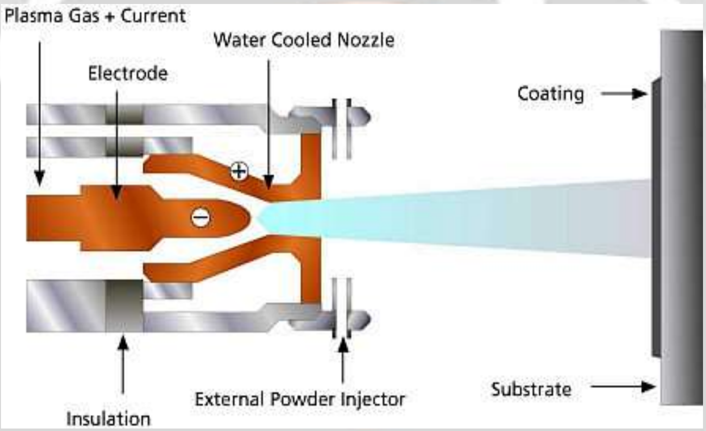

Fig: 2.3 .Schematic diagram of the plasma spraying process

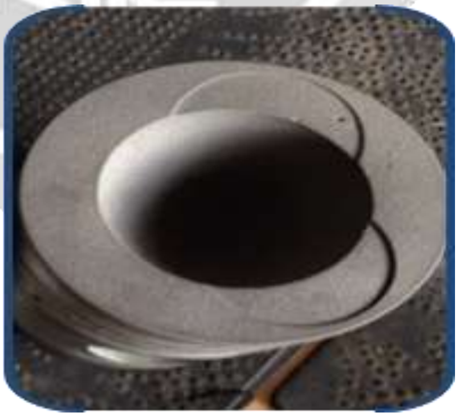

Fig: 2.4.Piston before coating **Fig: 2.5 Piston after coating**

3.0 EXPERIMENTAL WORK:
Experiment is carried out in diesel engine with the following engine specifications as follow,
Procedure:

Initially experiment is done on conventional engine fuelled with Mamey Sapote biodiesel blends of 15% 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.
e. exhaust emissions such as CO2,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

Table No1: Engine specifications

Make and Model	**Research Engine Test setup code 240 PE Apex innovations pvt.Ltd.**
Type of Engine	Multi fuel
Number of Cylinders	Single cylinder, Four Stroke
Cooling Media	water cooled,
Rated Capacity	3.5 KW @ 1500 rpm,
Cylinder diameter	87.5 mm
Stroke length	110 mm,
Compression ratio range	12-18
Injection variation	0- 25 ^{o} BTDC
Dynamometer	Eddy current Dynamometer
Overall dimensions	W 2000 x D 2500 x H 1500 mm

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Fig: 3.1 Experimental Setup

Table No: 2.2 Properties of Mamey Sapote oil

Properties	Mamey Sapote oil	Biodiesel
Density at 15^0 C (g/cm^3)	0.887	0.875
Kinematic Viscosity at 40^0 C(mm^2/s)	34.75	4.65
Calorific Value (MJ/Kg)	38.12	37.2
Flash Point (^{0} C)	197	173
Pour Point (^{0} C)	-6	3
Acid Value mg KOH/g	3.79	0.15
Iodine value g Iodine/ 100 g	65.02	65.28
Specific gravity	0.902	0.871

4.0 RESULTS AND DISCUSSIONS:

4.1. Brake specific fuel consumption: Fig: 4.1 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 B 15 of Ni-Cr coated engine compared to conventional engine. Therefore it appears that the thermal barrier coatings have considerable influence at reduction in Brake specific fuel consumption It is mainly due to the higher temperature reached in the combustion chamber

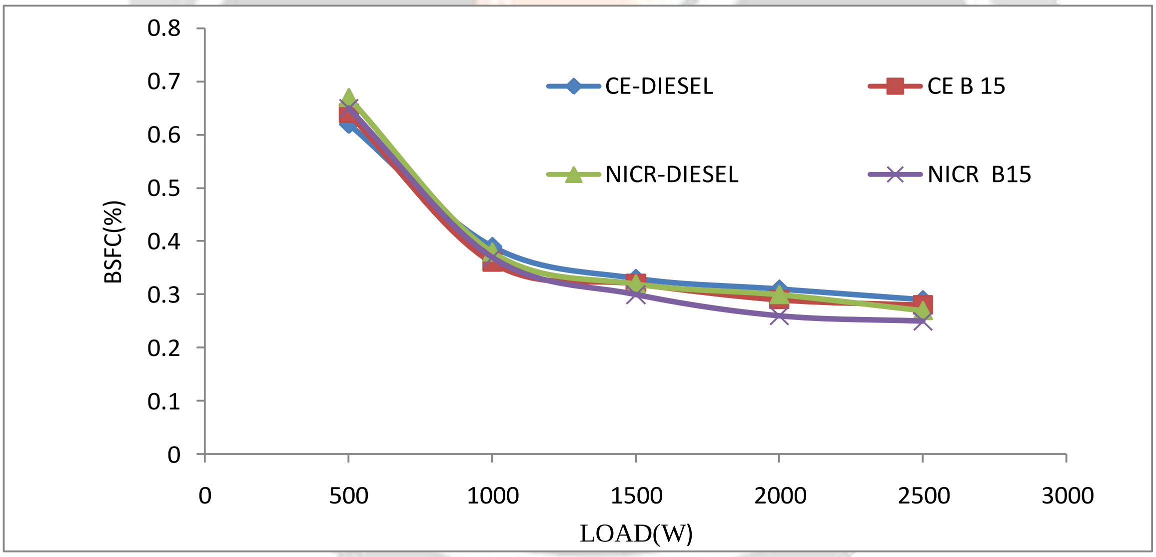

Fig: 4.1 .Load vs Brake specific fuel consumption

4.2. BRAKE THERMAL EFFICIENCY: Fig 4.2 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 B 15 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

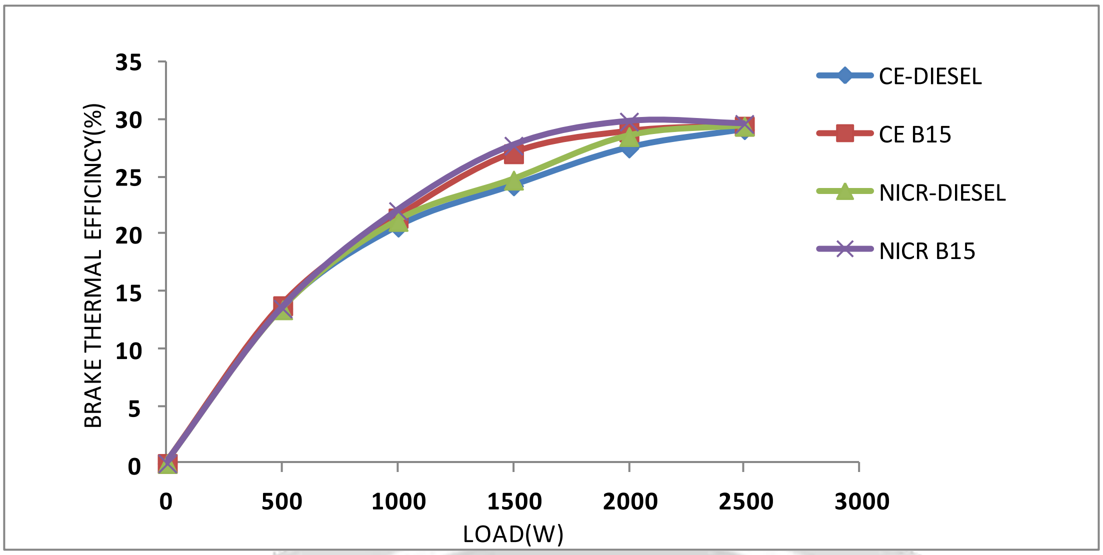

Fig: 4.2. Load vs Brake thermal efficiency

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4.3. EXHAUST GAS EMISSIONS OF CARBON MONOXIDE: Fig: 4.3 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.

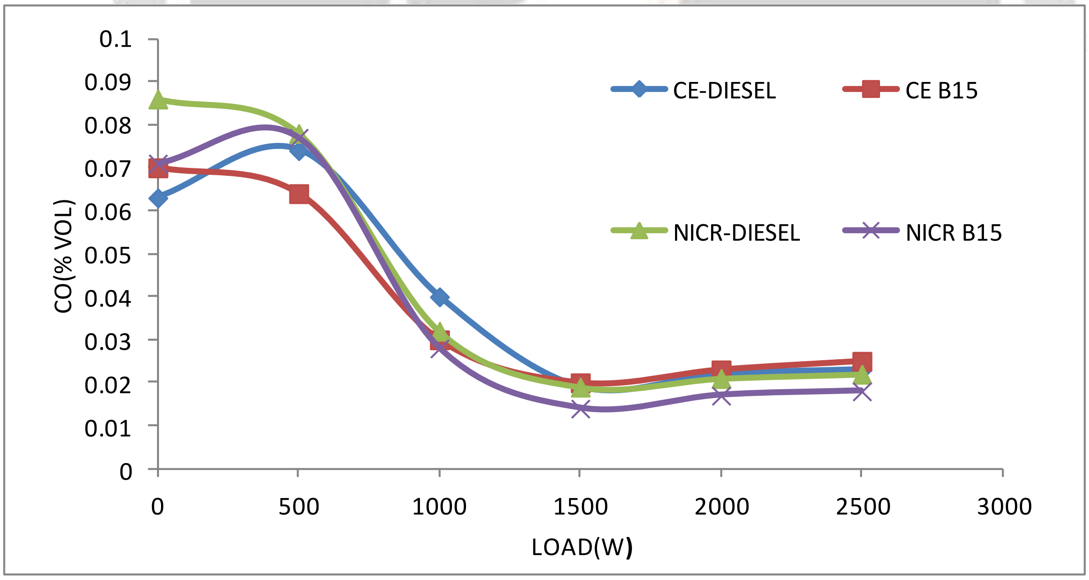

Fig: 4.3. Load vs CO emissions

4.4 EXHAUST EMISSIONS OF HYDRO CARBONS: Fig:4.4 shows 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 B15 of coated engine compared to conventional engine. It is due to high after combustion temperature leads to complete combustion of fuel in the engine. Combustion chamber temperature is inversely proportional to HC emission. So HC emissions are lower in coated engine as compared to conventional engine.

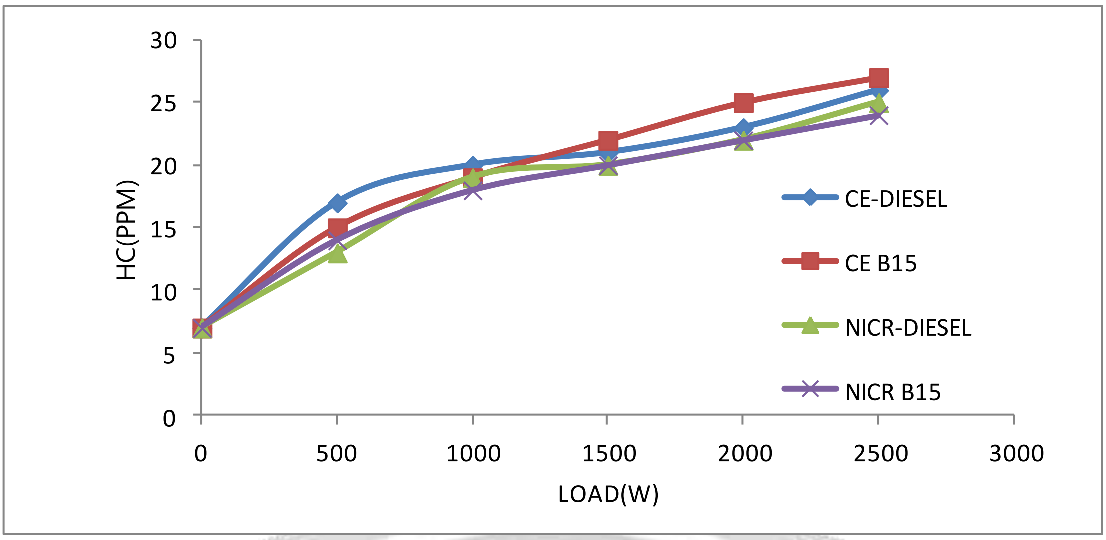

Fig:4.4 . Load vs HC emissions

4.5. EXHAUST EMISSIONS OF NITROGEN OXIDES:

Fig : 4,5 shows the comparison of hydrocarbon emission for different loads of conventional engine and coated engine. 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 Mamey Sapote (B15) blend. 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. The temperature and availability of oxygen are two favorable conditions to form NOx.

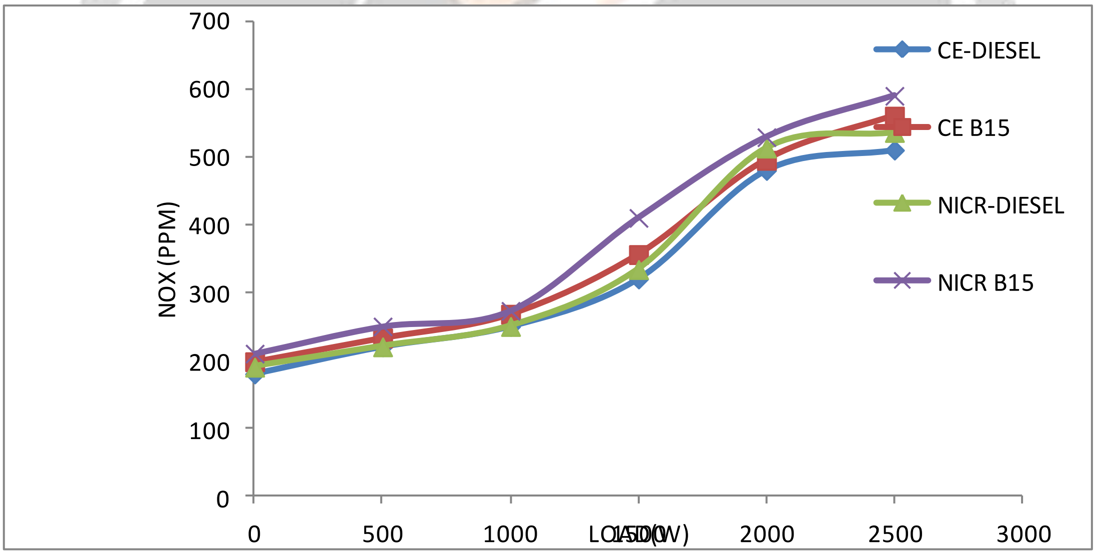

Fig: 4.5. Load vs NO_X emissions

4.6. Exhaust emissions of carbon dioxide: Fig shows the comparison of hydrocarbon emission for different loads of conventional engine and coated engine. From fig it is observed that CO_2 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 CO_2 emissions in coated engine compared to conventional engine.

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.

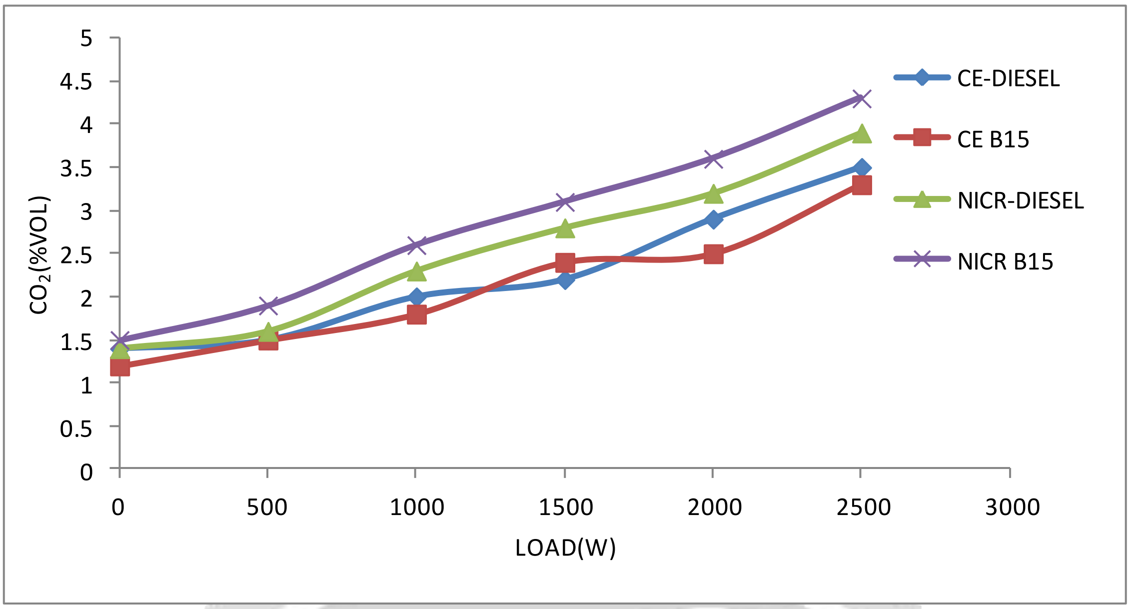

Fig: 4.6. Load vs CO_2 emissions

5.0 CONCLUSIONS:

An experimental investigation of the effect of Nickel-Chromium coating on diesel engine fuelled with Mamey Sapote(B15) bio-diesel is conducted.
Based on experimental investigation it can be concluded that Soap nut oil can be suitable substitute for diesel and Nickel-Chromium coating enhances engine performance and reduce emissions.

- The BSFC is reduced about 8-11% for diesel and blend B15 of Ni-Cr coated engine as compared to conventional engine.
- The brake thermal efficiency is found to increase by 1% for diesel and blend B15 at 80% load of Ni-Cr coated engine as compared to conventional engine.
- Lower CO emissions are produced in Ni-Cr coated engine when compared to conventional engine.
- The coated engine has lower UHBC emissions compared to the normal engine.
- The NOX emissions are higher in Ni-Cr coated engine as compared to conventional engine.
- CO_2 levels were lower in conventional engine while they were higher in Ni-Cr coated engine.

6.0 REFERENCES

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