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EXPERIMENTAL INVESTIGATION OF PERFORMANCE AND EMISSION CHARACTERISTICS OF HONGE OIL ON COATED PISTON WITH DIMETHYL CARBONATE AS AN ADDITIVE

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Abstract:oil and petroleum products will become very costly and scarce. Efforts are being made throughout the world today to reduce consumption of liquid petroleum fuels wherever it is possible. With increased use and depletion of fossil fuels, alternative fuels technology will become more essential. This led to the search for an alternative fuel which should be not only environment friendly but also sustainable without compromising on the performance. Many alternative fuels such as It is believed that crude Jatropha oil, Honge oil, canola oil and citronella oil gave improved performance and they are renewable, clean burning and having properties analogous to that of diesel.

Today, in developing countries like India, most of the transport vehicles are run on the diesel fuel. Diesel fueled vehicles discharge significant amount of pollutants like CO, HC, NOx, lead, soot which are harmful to the environment. Also the world's fossil fuel reserves are depleting rapidly due to enormous growth of population and increased usage of technology.

The biodiesel fuels are most promising alternative among the different diesel alternatives. However high viscosity, poor volatility and cold flow characteristics of biodiesel fuels can cause some problems such as injection chocking, severe engine deposits filter gumming, piston ring sticking and thickening lubricant oils from long term Diesel engines.
Such problems can be eliminated by thermal barrier coating (insulation) on engine parts such as cylinder head, piston crown, valves etc. by atmospheric plasma spray technique. 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 beimproved when compared with the without coated piston.

The objective of present work is determine the performance and emission characteristics of 4-stroke single cylinder diesel engine using honge oil with dimethyl carbonate as an additive on Chromium Carbide coating on piston crown as thermal barrier.

Keywords: Honge oil, Diesel engines performance, Chromium Carbide Coating, Dimethyl Carbonate, UHC- Unburned hydro carbons, CO- Carbon monoxide, NOx emissions.

1.INTRODUCTION

The definition of engine is to convert heat in to work called heat engine. In this heat is low grade energy and work is high grade energy. Heat engines are either external combustion engines or internal combustion engines. The Internal combustion engines having higher efficiency than the external combustion engines and emits fewer pollutants in this diesel used as a fuel. The main idea of alternative fuels is good reserves in the sector of transportation because they will not only assist to the environmental quality but also has distinct positive socioeconomic results. From last century many number of scientists had suggested that the bio-fuels are good alternatives to fossil fuels.In present research we will introduce Honge oil as an alternative fuel. In present experimental investigation we are purchased Honge oil at Falcon (Exports & Imports of natural essential oils) in Bangalore. In present day's major pollutants from automobiles are unburned hydrocarbons (UHC), oxides of Nitrogen (NOx), Carbon monoxide (CO), sulfur compounds and lead compounds and particulates.

Brake thermal efficiency increase as the oxygen content of DMC helps in complete combustion. DMC reduces the emissions from the engine. It improves the engine performance. Carbon monoxide and smoke content decreases as carbonate content increases.

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2. PRODUCTION OF BIODIESEL

Honze oil is an oil bearing tree, which is non-edible and does not want any suitable application with only 6% being utilized out of 200 million tons per annum; Honze is a native to humid and subtropical environment saving annual rainfall from 500 to 2500mm in its natural habitat. The maximum temperature ranges from 27 to 38°C and the minimum is 1 to 16°C. It can grow on most soil types ranging from stony to sandy clay including verticals. It doesn't do well in dry sands. It is highly tolerant to salinity. It can be propagated either by seeds or root suckers. The yield of kernels per tree is 8 to 24 kg.

The freshly extracted honze oil is yellowish orange to brown and rapidly darkens on storage. It has disagreeable odour and bitter taste.

The oil has several furan Xeons such as Karajan, ponga pin, and pongamia brim. The presence of toxic Xavonoids makes the oil non-edible. At present the oil is being used as a raw material for soap, and after sulphating and sulphation in the leather tanning industries, the main constraints for its more usage are the colour and odour.

3 PREPARATION OF BIODIESEL BY TRANS ESTERIFICATION PROCESS

Transesterification process is the reaction of triglyceride (fat/oil) with an alcohol in the presence of acidic, alkaline or lipase as a catalyst to form monoalkyl ester that is biodiesel and glycerol. The presence of strong acid or base accelerates the reaction. The main purpose of trans esterification is to reduce the high viscosity of oil which is suitable for CI engine. In this project, karanja methyl ester (KOME) is obtained by reacting honze oil with methanol in the presence of base catalyst. The honze oil is first filtered to remove solid impurities then it is preheated at 100°c for an hour to remove moisture. A two stage process is used for Tran's esterification of honze oil. The first stage is esterification to reduce fatty acids content in honze oil with methanol (99% pure) and acid catalyst (98% pure) heated for one hour at 60-65°C on magnetic stirrer. After esterification, the esterified oil washed using water. The washing is carried out in a separate funnel. The hot water having temperature as that of esterified oil added in a separate funnel. Impurities like dust, carbon content; Sulphur content is washed away with water. After washing, the esterified oil was fed to the Trans esterification process. The solid catalyst (1%by weight) was dissolved in methanol and added into esterified honze oil while heating. This mixture is heated for 60 min. Once the reaction is complete, it is allowed for settling for 10-12 hours in a separating funnel. The products formed during Trans esterification were honze oil methyl ester and glycerin. The bottom layer consists of glycerin, excess alcohol, catalyst impurities and traces of non-reacted oil. The upper layer consists of clean amber colourhonze oil methyl ester. After settling, the glycerin layer is removed. The separated biodiesel is taken for characterization. PH had been checked regularly during esterification and transesterification reaction. A successful Transesterification reaction is signified by the separation of the ester and glycerol layers after the reaction time.

PROPERTIES OF HONGE OIL

Properties of honze crude oil and pure biodiesel obtained from Trans esterification process were measured at chemistry department and research & development, mechanical Engineering department of KITS, Ramtek shown below table.

S. No.	Property	unit	Honze oil	B100
1	Density	gm/cc	0.926	0.905
2	Viscosity	Pa-sec	41.8	8.9
3	Flash point	°C	225	150
4	Calorific value	KJ/kg	30,075	36,541.56

Table 1 Properties of honze crude oil

PROPERTIES OF DIESEL AND BIODIESEL BLENDS

Properties of diesel and biodiesel blends with diesel are measured at G.K.V.K College at Bangalore.

Items	Pure diesel	10%honge oil +diesel	20%honge oil +diesel	30%honge oil +diesel	40%honge oil +diesel
Kinematic viscosity (CS)	4	5.2	5.5	5.9	6
Specific density(g/cm^3)	0.850	0.843	0.85	0.867	0.889
Calorific value (kJ/kg)	42,000	40,420	39,150.2	38,840.2	37,615
Flash point (°C)	65	65	67	70	74

Table 2 Properties of honzeoil and Biodiesel Blends

FUEL ADDITIVES

Fuel additives are chemical substances that are added to gasoline, diesel, Kerosene and other fuels impart or improve certain properties. There are many different types of products. Common types of fuel additives include acetone, ether, nitrous oxide (nitrous), nitromethane (nitro), butyl rubber, forex, oxy-hydrogen, ferrous picrate, silicone and other anti-foaming agents, and tetra- nitromethane. Gasoline treatments, fuel injector cleaners, fuel injector treatments, octane boosters, diesel fuel treatments, and water removers are also available. Additional categories of fuel additives include antioxidants, hybrid compound blends, oxygenates, antiknock agents, leader scavengers, fuel dyes, metal deactivators and corrosion inhibitors. Oil additives and fluid additives are related products.

Selecting fuel additives requires an understanding of product capabilities. Ether and other flammable hydrocarbons are used as starting fluids in hard-to-start diesel engines. Both nitrous oxide (nitrous) and nitromethane (nitro) are used in auto racing and other high-performance applications. Acetone is a vaporization additive used mainly with methane racing fuel. Butyl rubber is a detergent for diesel fuel injectors while forex is an engine catalyst that improves fuel economy and reduces emissions in gasoline engines. Ferrous picrate and oxyhydrogen are also used to improve fuel mileage. Silicon is used as anti-foaming agent in diesel engines. Fuel additives such as tetra nitromethane can help to improve the combustion properties of diesel fuel.

Oxygenated fuel additive is nothing but more than fuel has a chemical compound containing oxygen. It is used to help fuel burn more efficiency and cut down on some types of atmospheric pollution. It can also reduce deadly carbon monoxide emissions.

DIMETHYL CARBONATE:

Dimethyl carbonate (DMC) is an organic compound with the formula OC $(OCH_3)_2$. It is a colorless, flammable liquid. It is classified as a carbon ester. This compound has found use as a methylating agent and more recently as a solvent that is exempt from classification as a volatile organic compound (VOC) in the US. Dimethyl carbonate is often considered to be a green reagent.

Properties of Di Methyl Carbonate (DMC)

S.NO	PROPERTY	
1	Chemical formula	$C_3H_6O_3$
2	Molecular weight	90
3	Density (g/ml)	1.70
4	Net lower heating valve(kj/kg)	15,780
5	Stoichiometric air-fuel ratio	4.665

6	Viscosity(mm^2/sec)	0.625
7	Auto Ignition Temperature (ºC)	220
8	Flash point(ºC)	18
9	Oxygen (Mass %)	53.3

Table 4 Properties of Di Methyl Carbonate

***Benefits of dimethyl carbonate** (DMC):*

- Brake thermal efficiency increase as the oxygen content of DMC helps in complete combustion.
- DMC reduces the emissions from the engine.
- It improves the engine performance.
- Carbon monoxide and smoke content decreases as carbonate content increases
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4EXPERIMENTAL SETUP

Engine Specification

Make	KIRLOSKAR
Type	Single cylinder, four strokes, water cooled
Capacity	5 HP
Bore Diameter	80 mm
Stroke length	110 mm
Speed	1500 rpm

Table 5: Engine specifications

Eddy Current Dynamometer Temperature Points

1. Inlet
2. Water inlet to engine
3. Water inlet to calorimeter
4. Water outlet from engine
5. Water outlet from calorimeter
6. Exhaust gas inlet to calorimeter
7. Exhaust gas outlet from calorimeter

Engine procedure

The experimental work had conducted on 4-stroke diesel engine. In diesel engine four strokes are utilized namely suction, compression, power and exhaust strokes for completion of cycle. The 4-stroke diesel engine consists of two valves i.e., inlet valve and exhaust valve. In this the inlet valve is used for sucking the fuel charge or pure air into the chamber at beginning of suction stroke and the exhaust valve is used for removal of exhaust gases from engine cylinder at the end of combustion stroke. The piston is moving from top dead center to bottom dead center at starting the cycle. The piston begins from TDC to BDC at suction stroke the inlet valve opens and the fuel charge is sucked into the combustion chamber then compressed at compression stroke. At end of compression stroke spray of fuel injected into the cylinder the fuel complete combustion obtained in cylinder at power stroke. End of power stroke the exhaust gases are released. The exhaust gases are sent to out through exhaust manifold at exhaust stroke. This cycle follows by 4-stroke diesel engine.

Engine Equipment

A single cylinder 4-stroke water cooled diesel engine having 5 HP as rated power at 1500 rpm was used for the research work. The engine was coupled to an electrical dynamometer for loading it. The engine equipment is completely digital system. The speed and different temperatures is note down from the digital indicator. The equipment set-up of the engine is shown in figure.

Figure.4

Precautions:

1. Give the necessary electrical connections to the panel and also check the lubricating oil level in the engine
2. Check the fuel level in the tank

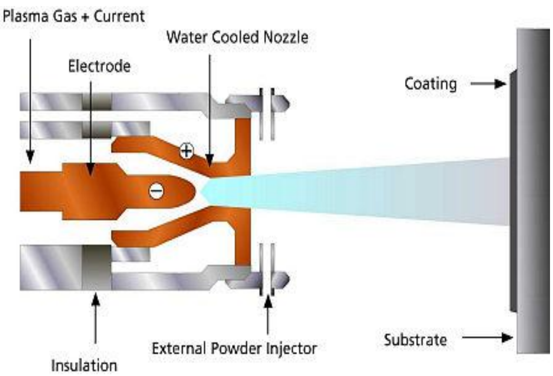
Procedure of experiment

1. Allow the water to flow to the engine and calorimeter and adjust the flow rate to 6 lpm& 3 lpm.
2. Release the load if any on the dynamometer.
3. Open the three-way cock, so that the fuel flows to the engine.
4. Start the engine by cranking.
5. Allow to attain the steady state.
6. Load the engine by switching on the loading switches.
7. Note the following readings for particular condition,
    a. Engine speed
    b. Time taken for 10cc of fuel consumption
    c. Rota meter reading
    d. Manometer readings, in cm of water &
    e. Temperatures at different locations
    f. Note pollution values from the pollution setup i.e., multi gas analyzer system.
8. Repeat the experiment for different loads at different fuel blends along with Dimethyl Carbonate additive on both non coated and coated pistons and note down the above readings
9. After the completion release the load and then switch of the engine.
10. Allow the water to flow for few minutes and then turn it off.

5 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 Chromium Carbide 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.



Schematic diagram of the plasma spraying process before coating after coating

6 RESULTS AND DISCUSSIONS

BRAKE THERMAL EFFICIENCY

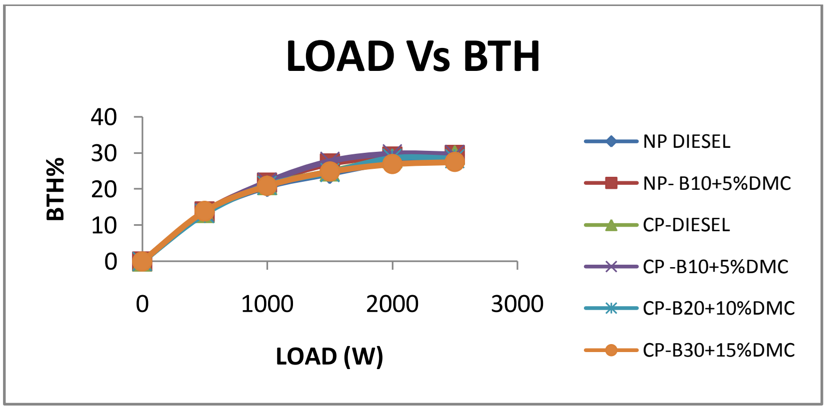


Figure 1 Represents the Variation of Brake Thermal Efficiency With Load For Different

Honge oil blends B10, B20, B30 of conventional engine. It is clear from the graph that B10 blend has high BTH as compared to other blends in conventional engine.

From fig 2, represents the comparison of Brake thermal efficiency of conventional engine to Chromium Carbide coated engine. The Brake thermal efficiency is found to increase by 1% for blends of Honge oil B10, B20 at 80% load of Chromium Carbide coated engine compared to conventional engine.

It is due to the fact that the coating material have low thermal conductivity, thereby providing a better insulation allowing a higher operating temperature and reducing cooling requirement which enhances the Brake thermal efficiency.

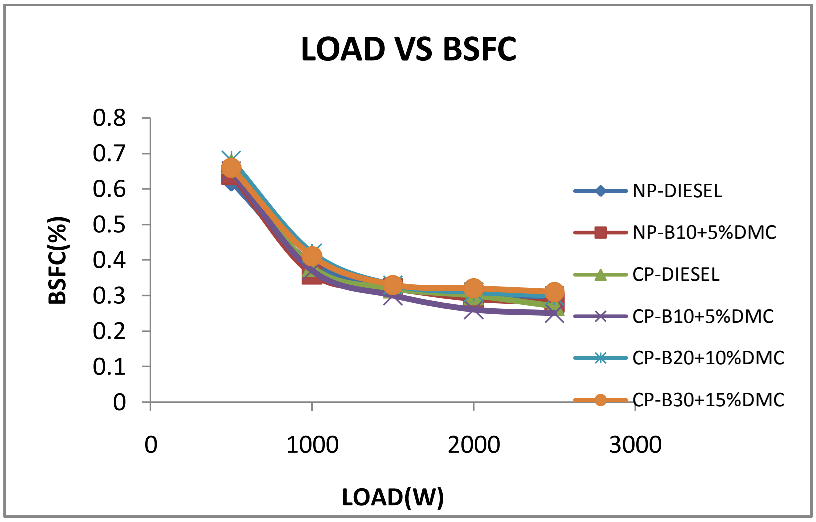


Figure 2 Represents The Variation Of Brake Specific Fuel Consumption With Load

Figure 2 represents the variation of Brake Specific fuel consumption with load for different Honge oil blends B10, B20, B30 of conventional engine. It is observed from graph that blend B10 has lower BSFC compare to other blends, whereas blend B20 almost same BSFC as diesel of conventional engine.

The comparison of BSFC of conventional engine to Chromium Carbide coated engine. The BSFC is reduced about 8-11% for blends of Honge oil in Chromium Carbide 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.

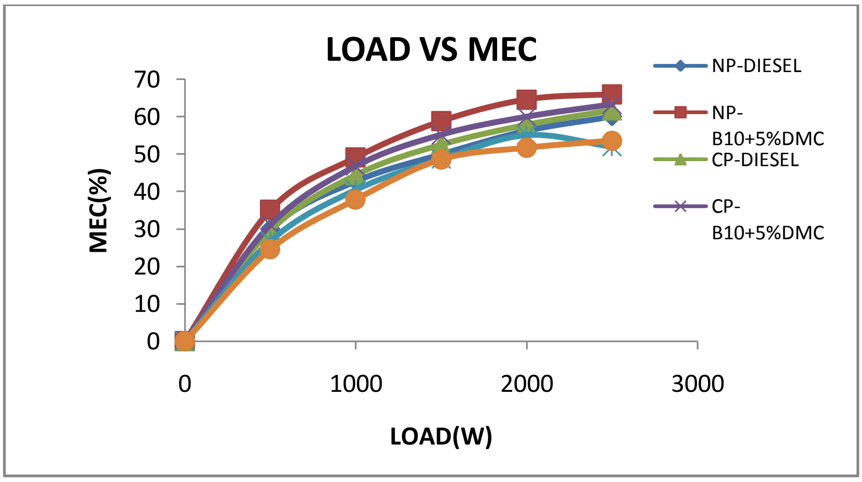
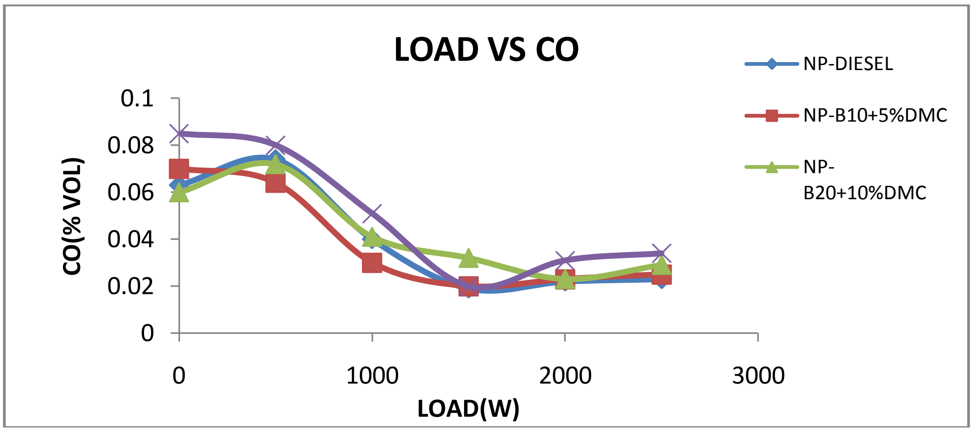


Figure 3 Load Vs Mechanical Efficiency

Figure 3 represents Honge oil blends B10, B 20, B 30 of conventional engine. It is clear from the graph that B10 blend has high mechanical efficiency compared to other blends in conventional engine.

Figure represents the variation of Mechanical efficiency with load of Chromium Carbide coated engine. There is increase in mechanical efficiency for the blends of coated engine compared to conventional engine due to increases of indicated power in the coated piston when compared to uncoated piton. The parameters affected the indicated power are brake power and friction power.



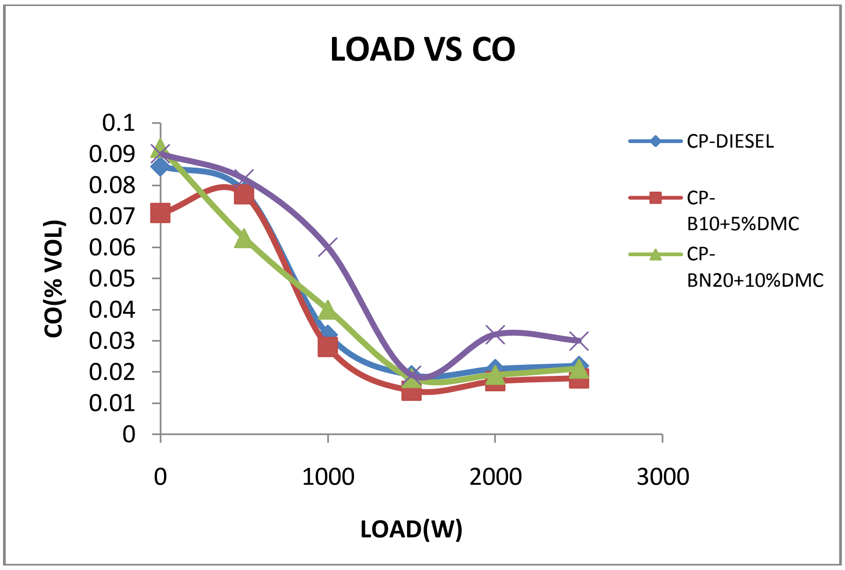
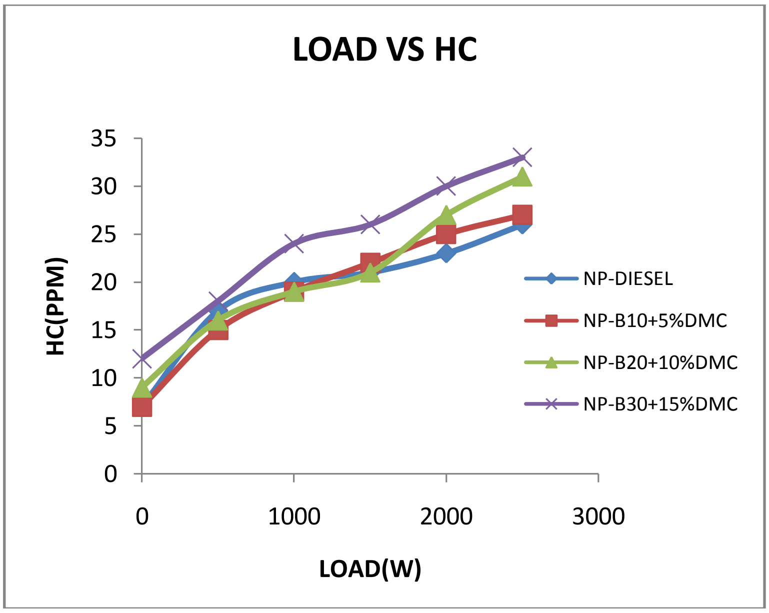


Figure4 represents the variation of CO emissions with load of conventional engine and coated engine respectively.

CO emissions of B10 blend is lower than diesel up to 60% of load and other blends like B20 , B30 has high CO emissions in conventional engine because of high viscosity and improper spray of fuel.

However CO emissions for B10, B20 are lower than diesel even at full load of Chromium Carbide coated engine 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.



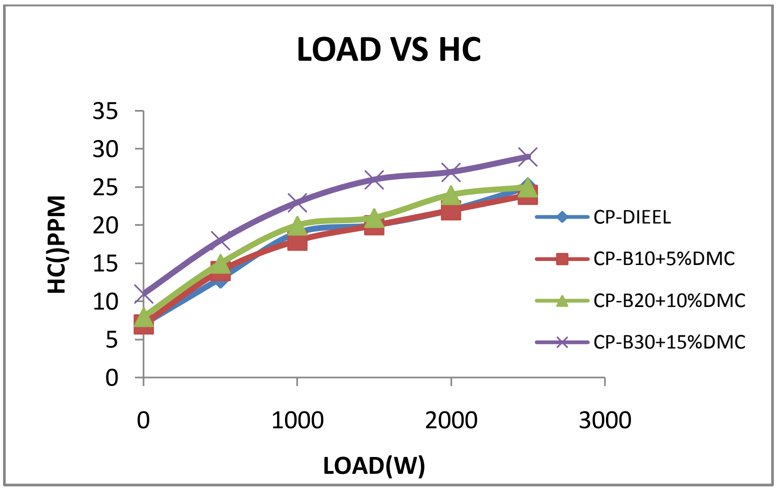
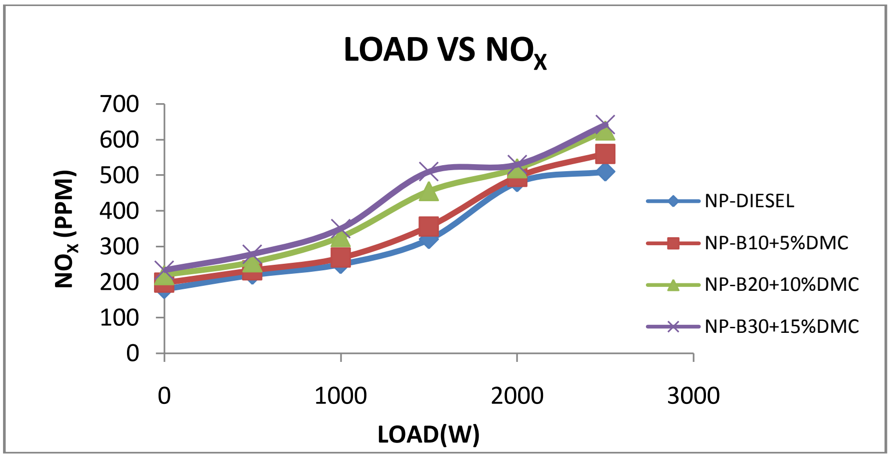


Fig 5 represents the variation of HC emissions with load of conventional engine and coated engine respectively.

HC emissions are generally produced because of improper combustion in the engine. Honge oil blends B10,B 20 has lower UHBC emissions compared diesel up to 60% of load. As the blend percentage increases, there is increase in the UHBC emissions due to the poor atomization of fuels at higher blends.

However UHBC emissions are reduced even at full load for all the blends B10, B20, B 30, because of the Chromium Carbide coated piston. It is due to high after combustion temperature leads to complete combustion of fuel in the engine.



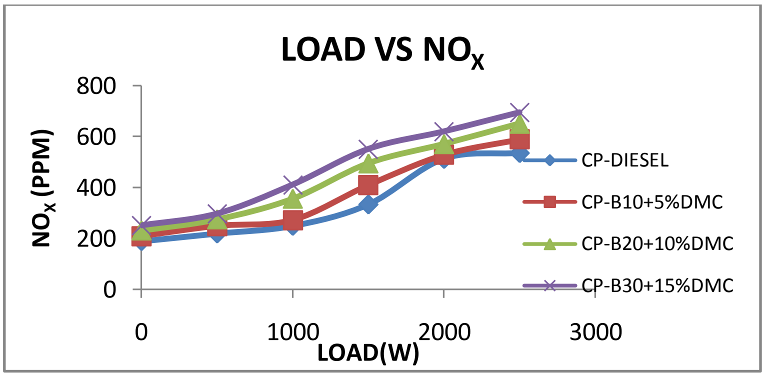
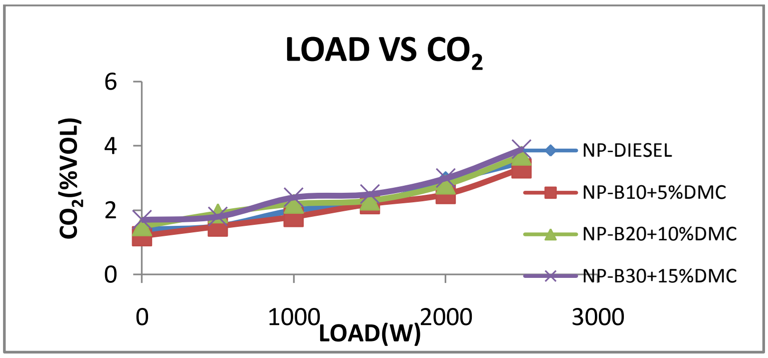


Fig 6 represents the variation of HC emissions with load of conventional engine and coated engine respectively.

Figure shows that NOx levels were lower in NP Engine while they were higher in Chromium Carbide coated engine at different operating conditions of the Honge oil blends at the peak load when compared with diesel.

This is due to increase of combustion temperatures with the faster combustion and improved heat release rates in Chromium Carbide coated engine caused higher NOx levels. The temperature and availability of oxygen are two favorable conditions to form NOx.



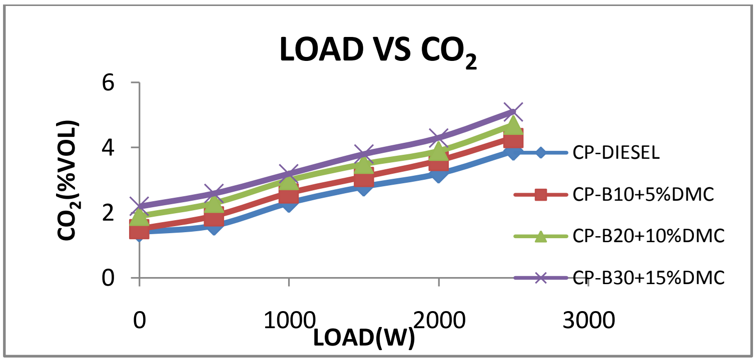


Fig7 Represents The Variation Of CO_2Emissions With Load Of Conventional Engine And Coated Engine Respectively

From fig it is observed that CO_2 levels were lower in NP Engine while they were higher in Chromium Carbide coated engine for different SN blends. This is due to the good oxidation property of chromium Carbide coating and DMC leads to complete combustion of fuel increases the CO_2 emissions in coated engine compared to conventional engine.

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