PERFORMANCE AND EMISSION ANALYSIS OF CI ENGINE FUELLED WITH THE BLENDS OF PALM OIL METHYL ESTERS AND DIESEL

[1]K.Sandeep Kumar, [2]Taj, [3]B. Prashanth

Assistant professor
Department of Mechanical Engineering,
MLR Institute of Technology, Hyderabad, India

***Abstract*: The two alarming situations in front of the engineers worldwide are to reduce the usage of conventional fuels and to reduce the ever increasing environmental pollution. This project is aimed to investigate experimentally the performance of DI diesel engine at varying loads when fuelled with the blends of Palm Methyl Esters (PME) and Diesel. The experiments were conducted on widely used diesel engine without design modifications. All the tests were conducted at steady state and constant speed. The effect of varying load was evaluated in terms of Brake Thermal Efficiency (BTE), Mass flow rate, Brake Specific Fuel Consumption, Exhaust gas temperature and Exhaust emissions by operating the engine with different blends of fuel. Experimental results showed that when the engine was operated with the blends of B0, B20, B40 and B60 at full loads the engine produced BTE's of 34.19%, 32.67%, 30.0% and 27.35% which are very close to that of the Brake Thermal Efficiency obtained with Diesel alone. This is due to better combustion of fuel particularly at the blend of B20 (32.67%) the thermal efficiency was closer to diesel is 34.19%. Particularly at full load CO emission was 0.025% for diesel and 0.02%, 0.012%, 0.007% for the blends B20, B40 and B60.The NO_X contents were found to be more for blends compared to diesel at all loads. This was due to the combustion and presence of intrinsic oxygen in the fuel blends. Based on the performance and emission characteristics, the B20 blend palm oil was found to be the optimum blend.**

***IndexTerms*— PME, thermal efficiency, vegetable oil, emissions, performance**

I. INTRODUCTION

Vegetable oil based fuels are biodegradable, non-toxic and significantly reduce pollution. They offer the advantage of being able to be readily used in existing diesel engines without modifications as their properties can be brought closer to diesel .They have a reasonably high cetane number. The flash point of vegetable oils is high and hence it is safe to use them. Vegetable oils typically have large molecules, with the presence of carbon, hydrogen and oxygen. They have a structure similar to that of diesel fuel, but differ in the type of linkage of the chains and have a higher molecular mass and viscosity. The presence of oxygen in vegetable oils raises the stoichiometric fuel air ratio. Contrary to fossil fuels, vegetable oils are free from sulfur and heavy metals. The heating value is lower at approximately 90% of diesel fuel. This property leads to an increase in the work that is necessary to spray vegetable oils in diesel engines therefore makes it difficult to break them up into fine droplets. The carbon residue of vegetable oils is higher than that of diesel, which leads to a smoky exhaust in a diesel engine. Vegetable oils do not add any extra carbon dioxide gas to the atmosphere, as opposed to fossil fuels, which are causing changes in the atmosphere. Carbon dioxide accumulation is thought to produce 'the greenhouse effect' which means that the atmosphere will get hotter, as if the earth were in a greenhouse and the climate will change accordingly. High winds, rising sea levels, droughts are a few of the probable results of continued burning of fossil fuels. The oil selected for the study is palm oil. Oil is converted into methyl ester by the transesterification process. Transesterification of the oil is done in QISCET Research laboratory to produce palm methyl ester.
Experimental results showed that when the engine was operated with the blends of B0, B20, B40 and B60 at full loads the engine produced BTE's of 34.19%, 32.67%, 30.0% and 27.35% which are very close to that of the Brake Thermal Efficiency obtained with Diesel alone. This is due to better combustion of fuel particularly at the blend of B20 (32.67%) the thermal efficiency was closer to diesel is 34.19%. Particularly at full load CO emission was 0.025% for diesel and 0.02%, 0.012%, 0.007% for the blends B20, B40 and B60.The NO_X contents were found to be more for blends compared to diesel at all loads. This was due to the combustion and presence of intrinsic oxygen in the fuel blends. Based on the performance and emission characteristics, the B20 blend palm oil was found to be the optimum blend.

S.Senthilkumar, Siddarth Manoharan "Investigation of palm methyl-ester bio-diesel with additive on performance and emission characteristics of a diesel engine under 8-mode testing cycle" (2015) Biodiesel is receiving increasing attention each passing day because of its same diesel-like fuel properties and compatibility with petroleum-based diesel fueled engines. Therefore, in this paper the prospects and opportunities of using various blends of methyl esters of palm oil as fuel in an engine with and without the effect of multi-functional fuel additive (MFA), Multi DM 32are studied to arrive at an optimum blend of bio-diesel best suited for low emissions and minimal power drop[1].

Vijayan.N, subha r."Effect of Process Parameters in the Production of Biodiesel through Transesterification – A Review" (2015) Available energy resources and rapidly changing environment has increased interest in the study of alternative sources of energy. To meet increasing energy requirements, there has been growing interest in alternative fuels like biodiesel to produce a suitable diesel oil substitute for internal combustion engines. Biodiesel can be produced from edible and nonedible oils through transesterification process. Transesterification process is flexible and economical conversion process of biodiesel when compared with others. Various parameters plays a role in the conversion process namely reaction time, molar ratio, type of catalyst, amount of catalyst, stirring time and operating temperature and its effects is investigated in this paper[2].

II. MATERIALS AND METHODS

II.I MATERIALS

In the present study palm oil is chosen for experimentation on direct injection diesel engine. Raw palm oil is collected from local oil supplier and Methanol and KOH were purchased from Local chemical store.

An experimental set up is configured with necessary instruments to evaluate the performance and emission of the compression ignition engine at different operating conditions. A single cylinder water-cooled four-stroke direct injection diesel engine (Kirloskar Engine) with a compression ratio of 16:1, developing 3.8kW at 1500 rpm is used for this work.

II.II PRODUCTION AND CHARECTERIZATION OF BIO DIESEL

Transesterification of PALM OIL methyl ester was done using Methanol in presence of KOH as catalyst to chemically break the molecule of raw palm oil into methyl esters of palm oil with glycerol as by product. Various proportions of palm oil methyl ester is mixed with diesel and Compositions of palm oil Biodiesel

Table 1: Composition of PME Bio diesel

S.No	Diesel	Palm Oil
1	100	0
2	80	20
3	60	40
4	40	60

The properties of bio diesel blends were evaluated experimentally and compared with that of base diesel. Various compositions of blends and properties of PME shown in TABLE 2

Table 2 Properties for Palm Methyl Ester

TYPE OF FUEL	FLASH POINT (°C)	FIRE POINT (°C)	KINEMATIC VISCOSITY (CST)	CALORIFIC VALUE KJ/Kg-k
Diesel	60	65	2.28	43500
B20	68	76	3.15	38282
B40	74	82	3.57	34059
B60	106	117	4.38	31056
B100	164	171	5.9	29500
IS For Biodiesel	120	130	2.5-6	37270

II.III EXPERIMENTAL SETUP

The setup as consists of Single Cylinder Four Stroke diesel engine connected to swinging field Dynamometer shown as shown in Fig.1. It is provided with necessary instruments for Combustion Pressure, Crank-Angle, Air Flow, Fuel Flow, Temperatures and Load Measurements. These signals are interfaced to computer through high speed data acquisition device. The set up has stand-alone panel box consisting of Air Box, Twin Fuel Tank, Manometer, Fuel Measuring Unit, transmitter for Air and Fuel Flow measurements, Process Indicator and Piezo Powering Unit. Rota meter are provided for cooling water and Calorimeter Water Flow measurement. Lab view based engine performance analysis software package "EngineSoft" is used for on-line performance evaluation. Multi gas analyzer Model MN-0 was used foe engine exhaust measurement. Specifications of engine are shown in Table 3.

Figure 1: 4-stroke single cylinder water cooled diesel engine setup

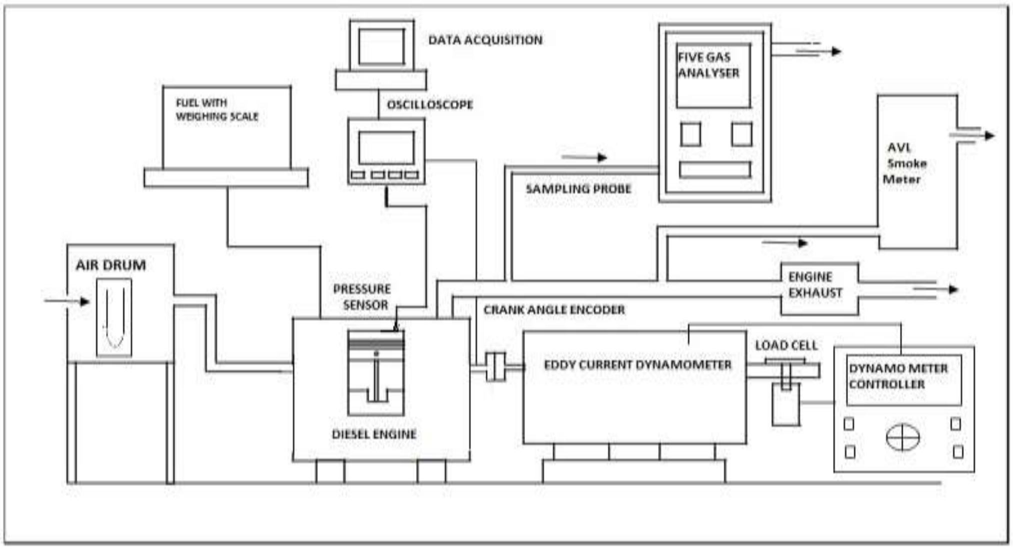

Table 3: Engine Specifications:

Engine Type	4-Stroke, single cylinder diesel engine
Make	Kirloskar
Maximum Brake Power	5HP
Rated speed	1500RPM
Bore (D)	80mm
Stroke (L)	110mm
Compression Ratio	16:1
Loading	Electrical loading by varying voltage
Dynamometer	swinging field dynamometer
Cooling	water cooling
Starting	By hand crank

.

II.IV EXPERIMENTAL PROCEDURE.

The engine performance test was conducted on single cylinder, four-stroke, naturally aspired, direct injection, water cooled, 3.7 kW output power with computerized diesel test rig. The engine was directly coupled to a swinging field dynamometer as shown in the Fig 1 and the engine characteristics are cited in specifications of engine. For every fuel change the fuel line was purged out of the residual fuel. The engine is made to run under full load for atleast 30 min to stabilize on new fuel conditions. Test-rig was provided with necessary equipment and instruments for recording the air flow, fuel flow, temperatures and load measurements. The fuel level and lubrications oil levels are checked and three way cocks is opened so that the fuel flows to the engine. The cooling water is supplied to the engine cooling water jacket. The electrical power is supplied to the panel instrumentation. The engine is unloaded by supplying 0 amp current to the electrical dynamometer. The engine is started by manual crank. The readings to be noted are: Load acting (in terms of voltage), time taken for 20 grams fuel consumption in seconds (t), manometer reading (cm), Inlet & Exhaust temperature of air, water inlet and outlet temperature, emission values (CO,CO_2,HC,NO_X). The experiment is repeated for different loads by changing the voltage.

III. RESULTS AND DISCUSSIONS

The optimum blend ratio is determined on the basis of specific fuel consumption, brake thermal efficiency, CO,CO_2, and oxides of nitrogen. For optimization, experiments were conducted using diesel and the various ester blends. The blend ratios were in steps of 20 percent up to maximum of 60 percent.

III.I Brake Thermal Efficiency

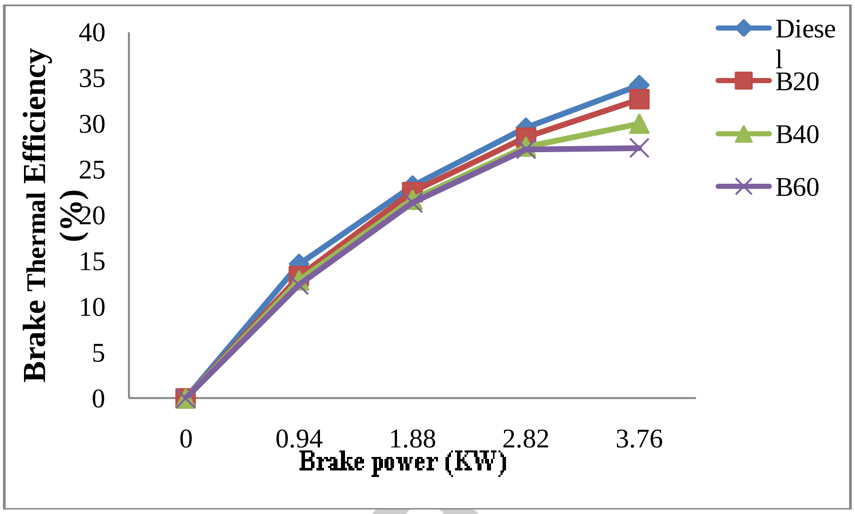

Fig 2 Brake thermal efficiency with different blends of PME oil

The variation of brake thermal efficiency of the engine with various blends as shown in Fig 6.2.1 and compared with brake thermal efficiency obtained with diesel. Among the blends B20 is found to have the maxium thermal efficiency of 32.67% at brake power 3.76 KW while for diesel it was 34.19% and for B60 it is decreased to 27.35%. It was observed that brake thermal efficiencies of all the blends were found to be lower at all load levels, the variation is significant particularly at higher loads. The decrease in brake thermal efficiency with increase in palm oil concentration is due to the poor mixing and evaporation of the blends due to their higher viscosity N.Vedaraman[3].

III.II Specific fuel consumption

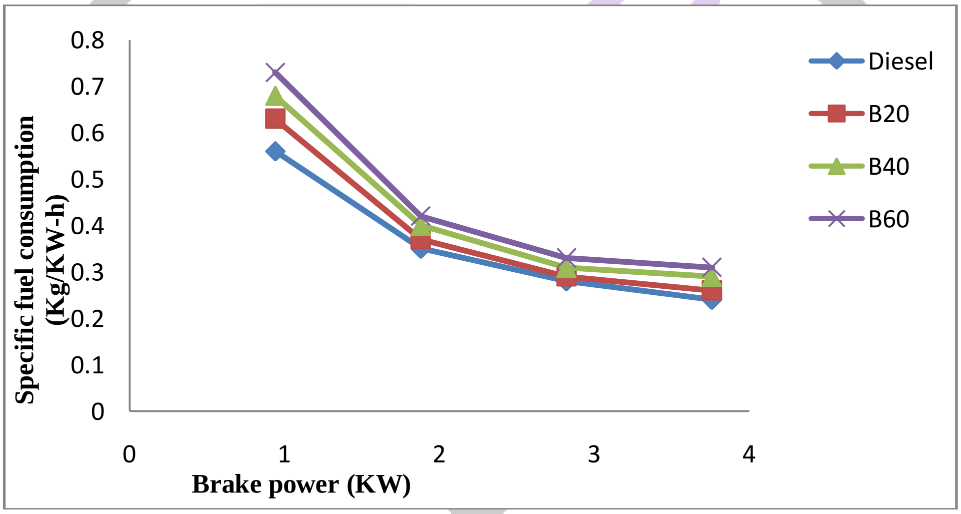

Fig. 3 Specific fuel consumption with different blends of PME oil

The variation of the brake specific fuel consumption of diesel and various blends of palm oil and diesel at different loads is shown in Fig 3. The specific fuel consumption is 0.26,0.29 and 0.31 Kg/KW-h for the blends B20, B40 and B60 respectively at full load while for diesel it is 0.24 Kg/KW-h at full load. The specific fuel consumption increases with increasing concentration of palm oil in the blend. This is because of the combined effects of lower heating value and higher fuel flow rate due to high density of blends. Higher proportions of palm oil in the blends increases the viscosity which in turn increased the fuel consumption due to poor atomization of the fuel. The increase in fuel consumption is found to be accordance with the results of S V Channapattana[4].

III.III Carbon monoxide Emissions

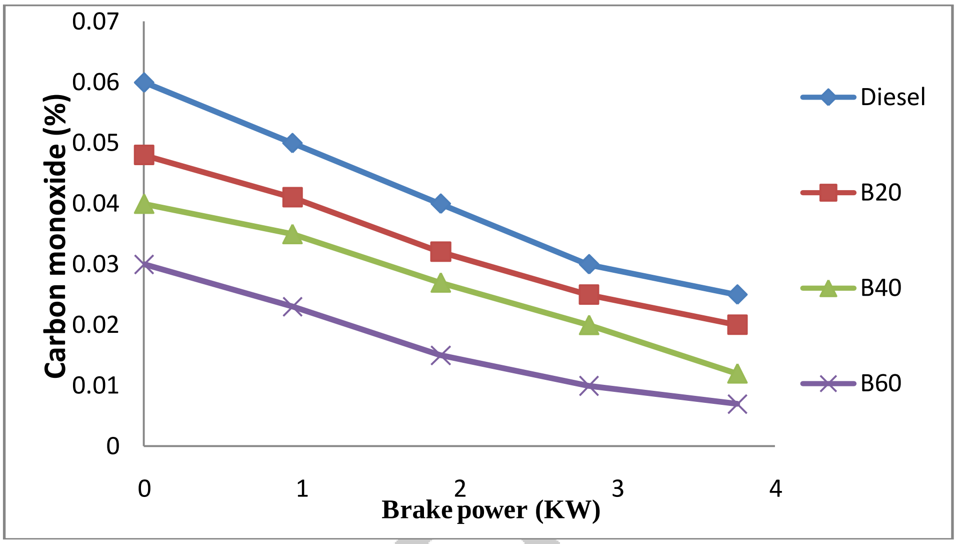

Fig 4 Carbon monoxide emissions with different blends of PME oil

The variation of carbon monoxide emissions of the engine with various blends is shown in Fig 6.2.3 and compared with the carbon monoxide emissions obtained with diesel. The CO emission is 0.02%, 0.012% and 0.007% respectively at full load while for diesel it is 0.025% at full load.The CO emissions decrease with increasing in the blend due to intrinsic oxygen content in the PME. It is observed that the CO emissions OF B60 is lower compared to other blends.

III.IV CO_2 Emissions

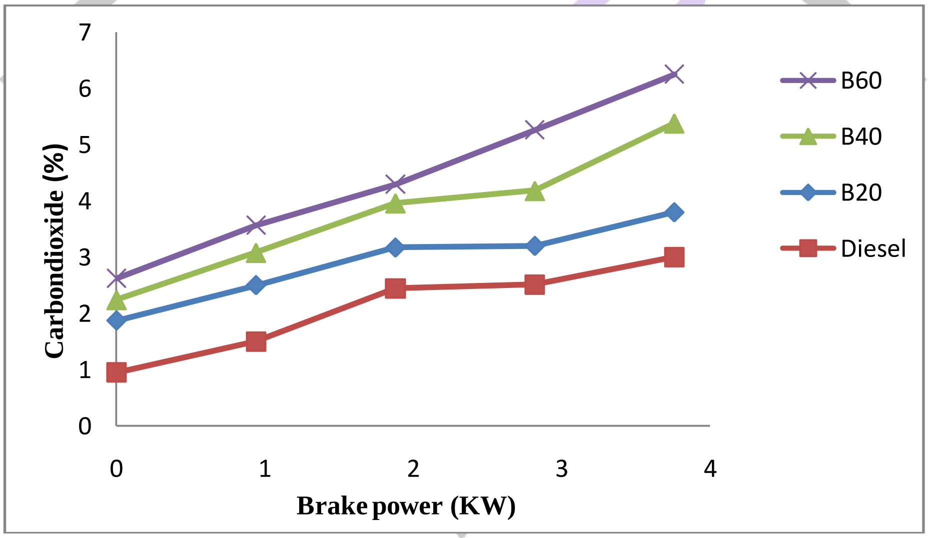

Fig 5 Carbon dioxide emissions with different blends of PME oil

The Fig 5 shows the emission levels of CO_2 for various blends and diesel. The CO_2 emission is 3.8%,5.38% and 6.25% respectively at full load while for diesel it is 3% at full load. The carbon dioxide emissions increases with increase in bend. Since palm oil is a oxygenated fuel, it improves combustion efficiency and hence increases the concentration of CO_2 in exhaust.

III.V HC Emissions

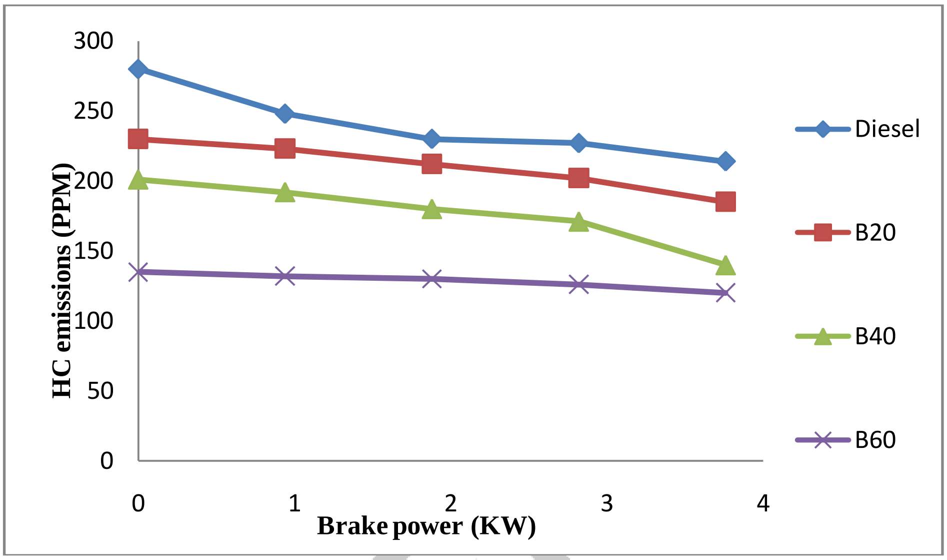

Fig 6 Hydrocarbon emission with different blends of PME oil

The comparison of HC emission for different biodiesel blends and diesel is shown in Fig6.2.6 . Hydrocarbon present in the fuel is burned inside the engine cylinder in the presence of oxygen. The amount of hydrocarbon, which is not taking part in the combustion reaction, is likely to come out as unburned hydrocarbon. In the case of POME, the oxygen present in the structure helps in better combustion and hence HC emission is less than that of diesel. The HC emissions reduce as percentage biodiesel increases in the blends.

III.VI NO_x Emissions

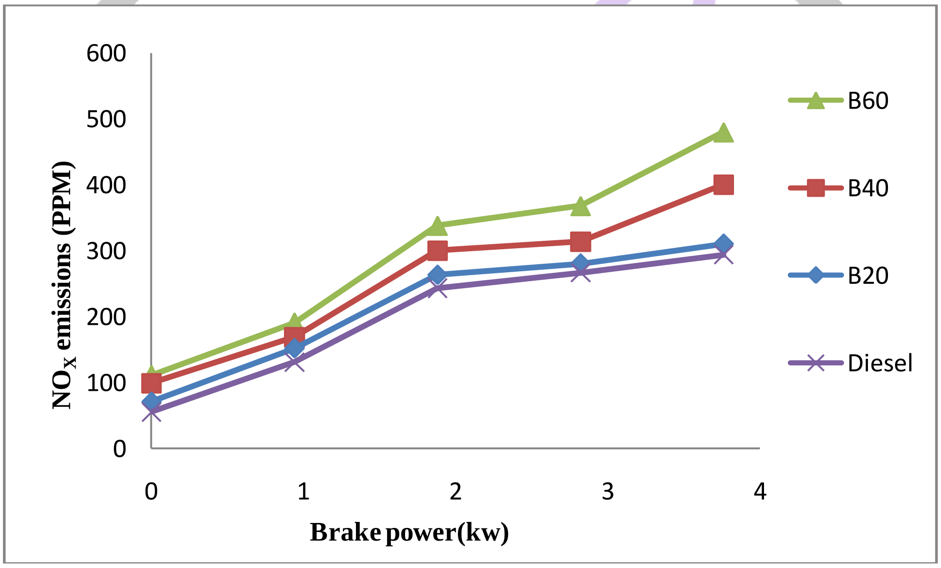

Fig 7 NO_x Emissions with different blends of PME oil

The comparison of NOx emissions for neat diesel, biodiesel, and various blends is shown in graph Fig 7 Oxides of nitrogen are formed inside the engine due to high flame,temperature, peak pressure inside the cylinder, nitrogen content of the parent fuel, and the residence time of fuel inside the combustion chamber. As Palm methyl is a vegetable-derived fuel, it has negligible nitrogen content and around higher oxygen content leads to better combustion, which in turn yields higher NOx formation. Another factor that influences injection timing and thereby NOx emission is density of biodiesel fuel. As the density of biodiesel is higher than that of diesel, it advances the injection time thus allowing the mixture more time in high-temperature region. Therefore, an increase in NOx emission is seen for biodiesel fuel when compared to neat diesel. The maximum NOx emission found for pure biodiesel sample is about 480 ppm and minimum for B20 blend is about 310 ppm.

IV.CONCLUSION

Based on the performance and emission parameters B20 has good BTE and CO_2 Emission, NO_X & HC Emissions which is at acceptable range. The Brake thermal efficiency value at maximum brake power for this optimum blend is 32.6% compared to 34.19% for base diesel. For the optimum blend mass of fuel consumption is 0.02Kg/KW-h higher compared to diesel due to low calorific value. The CO emissions are decreased with increasing in the blending ratio of palm biodiesel with diesel this is due to oxygen content present in the fuel. The CO_2 emissions increased with increased blending ratio of palm biodiesel to diesel because of complete combustion quality in palm biodiesel. UHC is decreased with increasing the load for all blends, palm oil is an oxygenated fuel which gives good combustion efficiency. So, less amount of unburned fuel in exhaust. NO_X Emission is increased with increasing the load this is due to the excess amount of oxygen supplied causes the higher NO_X Formation

REFERENCES

[1] **S. Senthilkumar Siddarth Manoharan** "Investigation of palm methyl-ester bio-diesel with additive on performance and emission characteristics of a diesel engine under 8-mode testing cycle" (2015).

[2] **Vijayan.N, subha r**."Effect of Process Parameters in the Production of Biodiesel through Transesterification – A Review" (2015)

[3] S **N. Vedaraman** "Preparation of Palm Oil Biodiesel and Effect of Various Additives on NOx Emission Reduction in B20: AnExperimental Study" (2011).

[4] **Channapattana.S.V** "Emissions and Performance Evaluation of DI CI - VCR Engine Fuelled with Honne oil Methyl Ester / Diesel Blends".

[5] **Vilas Nandedkar** " Prediction of Performance and Emission of Palm oil Biodiesel in Diesel Engine.

[6] **Venkata Ramesh Mamilla and M.V. Mallikarjun** "biodiesel production from palm oil by transesterification method" (2012)

[7] **Venkata Ramesh Mamilla and M.V. Mallikarjun** "Preparation of Biodiesel from Karanja Oil"(2011)