PERFORMANCE AND EMISSION ANALYSIS OF CALOPHYLLUM INOPHYLLUM BIODIESEL USING ISOBUTANOL AS ADDITIVE

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Abstract

In the present years, population of vehicles increased enormously which increases the demand of fossil fuel, The availability of conservative fuels decreased continuously, these reasons makes to find the alternative fuels especially bio fuels. The use of biodiesel considerably reduced emission and increase the performance of the engine.

Now a days researchers have reported the possibility for the production of biodiesel from non-edible oil jatropha curcus, pongamia pinnata etc. There is a best source of raw material that is calophyllum inophyllum oil for biodiesel production. In present study Calophyllum inophyllum is used as fuel in C.I engine.

Blends such as CIME10, CIME20, CIME30, CIME100 are taken for the experiment From the CIME20 blends produces good results and for this blend Isobutanol is added as fuel additive with concentration of 10%,15%. The Performance was improved and emissions were reduced by using Isobutanol with CIME20.

Keywords: Biodiesel, Calophyllum inophyllum, Fuel additive

I. INTRODUCTION

Due to the depletion of fossil fuels demand of alternative fuels are increased[1-2]. Several number of researches have done for the production of alternative fuels. alternative fuels are obtained by the vegetable oils or animal fats[3], production of alternative fuels can be done with the help of triglyceride from many different feed stocks like edible oils or non edible oils[4]

Sahid at el studied the use of biodiesel in CI engine by using edible oils such as soybean oil, sunflower oil, cotton seed oil [5],It can decrease the emissions produced in the engine but it has one limitation for the use edible oil as biodiesel i.e. edible oils are used as the food crops in daily life due to this unavailability of edible oils increased[6]. Soo-Young No is studied the use of non edible oil as alternative fuel for the C.I engine it can reduce the CO,HC emissions and slight increase in the NOx.[7-8]

calophyllum inophyllum biodiesel has high yield and it contains free fatty acids is the major limitation in the biodiesel and this can be reduced by using transesterification process[9]. Olubunmio studied the production of biodiesel from transesterification process It can reduce the viscosity of the biodiesel and increase the quality of the fuel[10-11], Ashok at el studied the calophyllum inophyllum biodiesel blends is used as a alternative fuel for the diesel engine to increase the engine performance and reduce the CO,HC emissions[12].

In the present study calophyllum inophyllum biodiesel blends are used as alternative fuel in the diesel engine. The different blends such as B10,B20, B30,B100 are taken in the CI engine and these blends characteristics are compared with the diesel. Fuel additives are added to the best blend obtained in the CI engine. Fuel additives are added to increase the performance characteristics of CI engine, Ashok at el studied the addition of fuel additives such as Ethanox and butylated hydroxy toluene to the biodiesel, from this two fuel additives Ethanox shows the good results compared to the other [13,14]. Isobutanol as fuel additive.N. Yilmaz et al studied the effect of Isobutanol fuel blends on the performance and emission characteristics of a diesel engine. In this due to the addition of butanol emissions increased or decreased slightly and BSFC also increased with the biodiesel [15-16]. H.M. Mahmudul studied impact of Oxygenated additive in the CI engine in this butanol is taken as fuel additive in the biodiesel from this slight reduction in the emission compared to the diesel[17]. In the present study Isobutanol is added in the best blend in the proportion of 10% and 15% and comparing this results with the conventional fuel.

II. PREPARATION OF BIODIESEL

The dry & cleaned calophyllum inophyllum fruits from the different sources are collected sufficiently. By peeling the calophyllum inophyllum dry fruits seeds has been extracted. The seeds are now used for producing raw oil. The seeds are gently cleaned and crushed in an oil mill. In the oil mill the seeds are fed into hopper and crushed by using helical grooves, due to high pressure, the seeds are crushed then raw oil & oil cake are the by products from this source. The oil recovery was calculated to be near about 27%. We extracted (200 – 250) ml of oil by grinding 1kg of calophyllum inophyllum seeds.

A. Esterification process

The calophyllum inophyllum crude oil was first heated to 45-50 °C and 1% (by wt.) sulphuric acid was added to the oil. Then methyl alcohol about (22-25)% (by wt.) was added. Methyl alcohol was added in excess amount to speed up the reaction. This reaction was proceed with stirring at 700 rpm and temperature was controlled at 55-60oC for 90 min with regular analysis of FFA after every 25-30 min. When the FFA was reduced up to 1%, the reaction was stopped. The major obstacle to acid catalyzed esterification for FFA is the water formation. Water can prevent the conversion reaction of FFA to esters from going to completion. After dewatering the esterified oil, it was fed to the transesterification process.

B. Transesterification process

In the present process the catalyst used is typically sodium hydroxide (NaOH) with 1% of total quantity of oil mass. It was dissolved in the 13% of distilled methanol (CH_3OH) using a standard agitator at 700 rpm speed for 60 minutes. The alcohol catalyst solution was prepared freshly in order to maintain the catalytic activity and prevent the moisture absorbance. After completion it was slowly charged into preheated esterified oil. After completion of this process the solution was poured in a separating funnel

Fig.2.1 Transesterification of biodiesel

C. Purification of oil:

The traces of the methanol from the oil can be removed in the next stage. In this process the CIME need to be washed with the distilled water and then it is heated at 75° C. The yield of this process found out to be around 85%.

D. Preparation of CIME blend with additives:

In this process additives are added to increase the performance characteristics,

Isobutanol is used as additive in the present work. the results obtained by the biodiesel blends can be compared with the conventional fuel from this best blend is taken for the addition of additive. In present work 10% and 15% concentration of Isopropyl alcohol is added to the CIME blend.

III. EXPERIMENTAL SETUP

The analysis is done on the computerized variable compression ratio (VCR) engine. The experiment is done at constant compression ratio (16.5) of the engine. Initially we have done the base line test with diesel, and then calophyllum inophyllum a bio diesel with blending such as CIME10,CIME20,CIME30 after that adding the fuel additives to the best blend obtained from the test results then we compare the obtained combustion, performance, emission values of CIME20+ISO with base line values.

A. Details of test rig and its specifications:

The VCR engine test rig is a computer based analysis engine by using different sensors and thermocouples. The sensors are used in the present test rig that are used to find the speed, torque, fuel consumption etc., k-type thermocouples are used in the test rig to measure the temperature at various points.

Engine specifications

- Engine: 4 stroke computerized variable compression ratio multi fuel direct injection water cooled engine
- Make: TECH-ED
- Basic engine: Kirloskar
- Rated power: 5 HP (DIESEL)
- Rated power: Up to 3 HP (PETROL)
- Bore diameter: 80mm
- Stroke length: 110mm
- Connecting rod length: 234mm
- Swept volume: 551cc
- Compression ratio: 5:1 to 20:1
- Rated speed: 1500 rpm

Initially the baseline test was conducted using diesel at various loads from no load to full load condition in five intervals (0%,25%,50%,75%,100%) . the performance and combustion are observed using engine test software which are loaded in the computer through interface The emission analysis is carried out Airval automation emission analyzer and AVL smoke meter The six gas smoke analyzer gives the percentage of CO (carbon monoxide) ,NOx (nitrogen oxide), SOx (Sulphur oxide), oxygen (O2), carbon dioxide (CO2), HC(hydro carbons) and smoke meter will gives the amount of smoke coming from the engine.

Fuel	Calorific Value (MJ/Kg)	Density In (kg/m^3)	Viscosity In(mm^2/s)	Flash Point (°c)	Cetane number
Diesel	41.88	849	2.6	93	54.6
CIME	38.5	878	4.18	146	51.2
Isobutanol	33.1	808	2.63	35	25

Table 1 Properties of Diesel, CIME, Isobutanol

IV. RESULTS AND DISCUSSION

A. PERFORMANCE ANALYSIS

BP v/s LOAD:

The BP v/s load graph will gives the information about the engine condition at different loads with respective to the BP is high at higher loads will ensure the use of that combination fuel the main consideration when working with any fuel BP and load are very more important when working with any fuel BP and load are very much important.

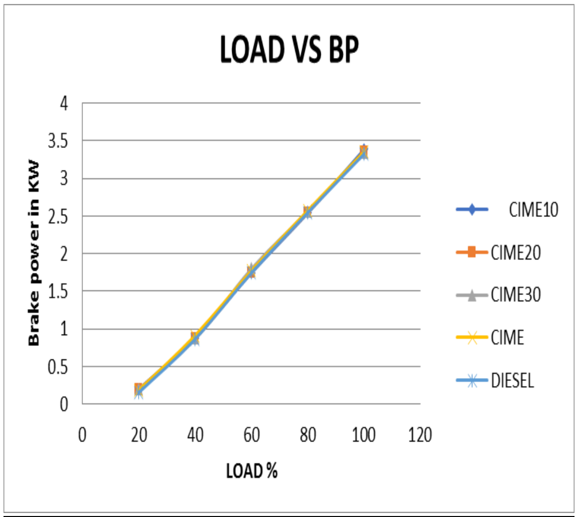

Fig. 4.1 LOAD v/s BP diagram

Observations:

1. By observing the graph BP varying linearly with respect to the Load

At 100% load CIME20 have highest BP.

BSFC v/s BP

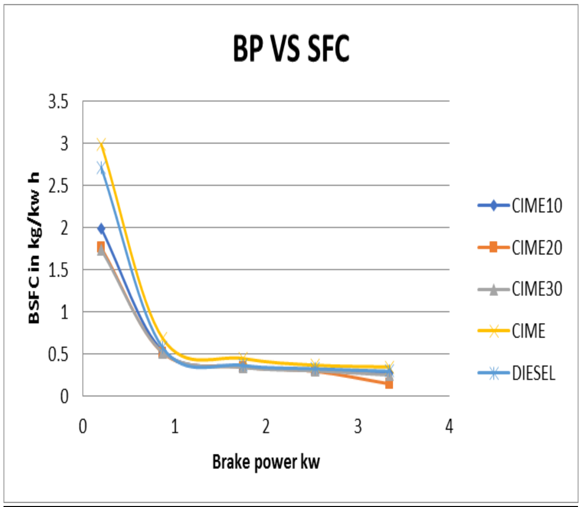

Fig. 4.2 LOAD v/s BSFC diagram

By observing BSFC v/s LOAD the BSFC is decreasing linearly for all fuel combinations w.r.t to the load. The indication of SFC is for economy. By comparing all fuel combinations the CIME20 having the lowest BSFC and CIME combinations having less fuel consumption. At full load specific fuel consumption decreases due to better conversion of chemical energy into heat energy due to reduced losses.

BP v/s Bthe:

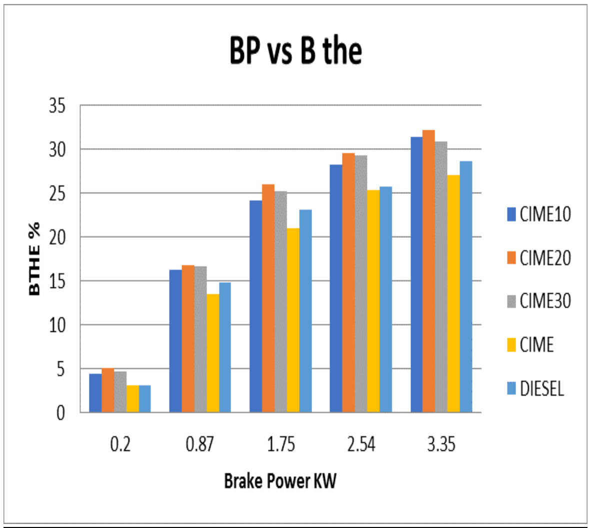

Fig. 4.3 BP v/s BTHE diagram

Bthe for various blends were observed. The plot of Bthe against brake power is shown in Fig. The comparison of Bthe for CIME10,CIME20, CIME30, CIME100 are shown in the graph. It is found that CIME20 gives better BTE at highest BP compared standard diesel. This may be attributed to extra oxygen content of biodiesel blends which improves the combustion process tending to increase in BTE of the engine.

B. Combustion Analysis:

P-V Diagram:

It is also called as indicated diagram the area under the P-V diagram will be the power developed per cycle with respective to the fuel combination. The IP will be calculated based on the diagram.

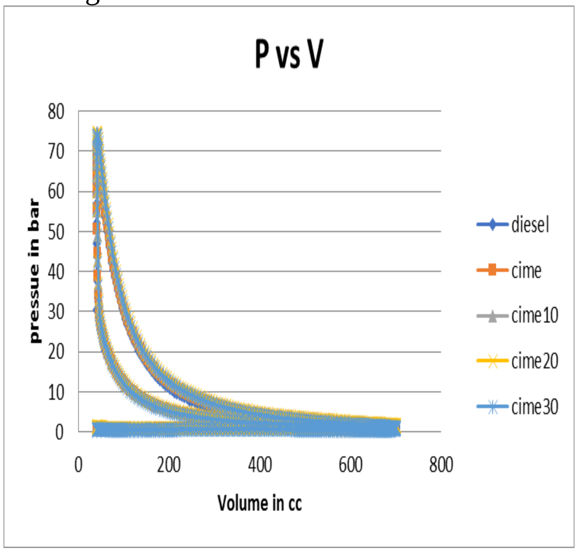

Fig 4.4 indicated (PV) diagram

By observing indicated diagram of the combination fuels, the P-V diagram for all the fuels are in the same way with small deviations. The CIME20 having the highest peak pressure when compared to all fuels then it will produce maximum power output.

One of the new observation in the P-V diagram is the suction line is in distribution, because variation in the suction pressure. The engine will suck the ambient air and is injected with some pressure that's why the deviations are occurred.

C. EMISSION ANALYSIS:

Load v/s CO:

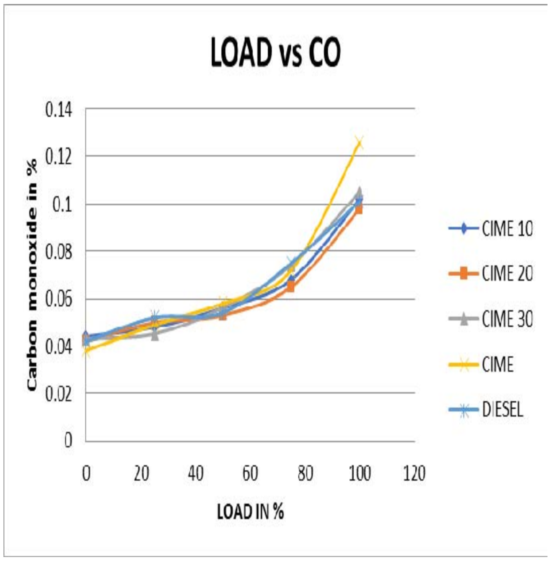

Fig. 4.5 Load vs CO

CO emissions from the engine occur due to partial oxidation of the fuel mixture. The rate of CO formation is a function of unburned fuel and mixture temperature during combustion. The variation of CO emissions against brake power is shown in Fig.4.5 .It is observed that CIME20 has low emission of CO, at part load as compared with neat diesel. The CO emission is increased for higher loads.

Load v/s HC

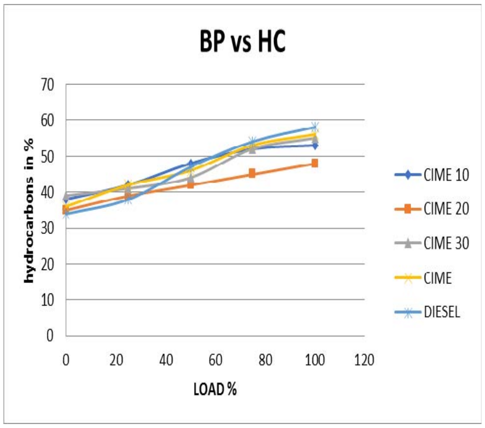

Fig. 4.6 Load v/s HC diagram

The comparisons of hydrocarbon emissions for straight diesel, biodiesel are shown in Fig.4.6 While compared with base diesel, hydrocarbon emission was found in decreasing .

Rate in CIME20.From the figure all the parameters has small variations .At full load condition CIME 20 has low hydrocarbon emission.

Load v/s NOx:

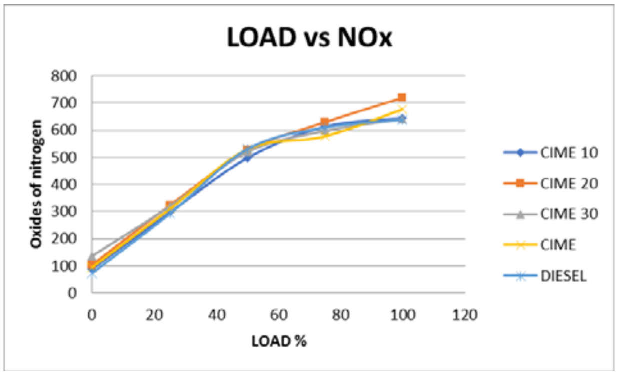

Fig. 4.7 Load v/s NOx

In this diagram increases the ignition delay resulting into reduced cylinder peak pressure temperature. From the above graph diesel has low emission compared to the other blends.

NOx formation rate depends upon in-cylinder gas temperature.NO X forms at high temperature burned gas regions. The comparison of variations of NOx emission with different blends substitution is shown in Fig. 4.7 There is a reduction was observed in NOx emission up to part load levels. It is evident NOx is increased by increasing the load. This may due to reduction in fresh air in the combustion.

D. PERFORMANCE ANALYSIS WITH ADDITIVES

It is observed that CIME20 has good performance characteristics compared to the other blends and diesel. To improve the performance characteristics of CIME20, fuel additives such as Isobutanol is added to the CIME20 in two different concentrations(ISO10% ,ISO15%).

BP vs BTH:

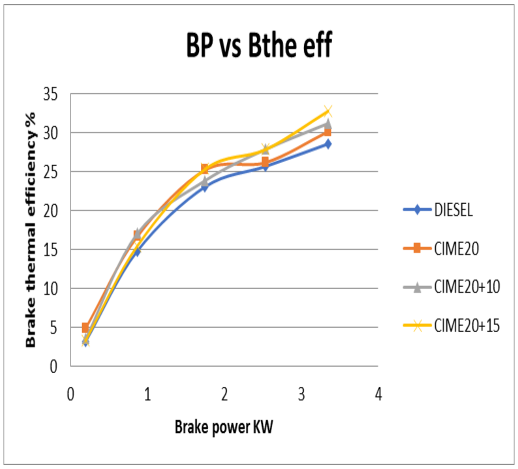

Fig.4.8 BP vs Bthe eff

It is observed that graph is drawn brake power against brake thermal efficiency.

From the graph CIME20+ISO15 has high thermal efficiency compared to the other blends compared to diesel. This may be attributed to extra oxygen content of biodiesel blends which improves the combustion process tending to increase in BTE of the engine.

BP vs SFC

Specific fuel consumption consideration is mainly for economic purpose at higher loads condition at which fuel will give low SFC value that is used as economic fuel.

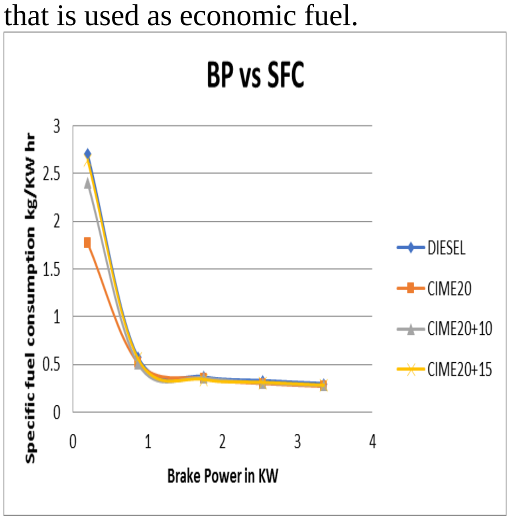

Fig.4.9 BP vs SFC

By observing BSFC v/s LOAD the BSFC is decreasing linearly for all fuel combinations w.r.t to the load. The indication of SFC is for economy. By comparing all fuel combinations the CIME20 +ISO15 having the lowest BSFC and CIME combination having less fuel consumption.

E. COMBUSTION ANALYSIS:

P-V DIAGRAM:

It is also called as indicated diagram the area under the P-V diagram will be the power developed per cycle with respective to the fuel combination. The IP will be calculated based on the diagram.

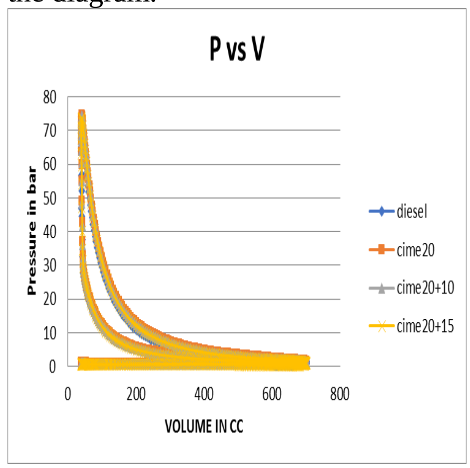

Fig.4.10 combined P-v diagram

F. EMISSION ANALYSIS:

Load v/s CO:

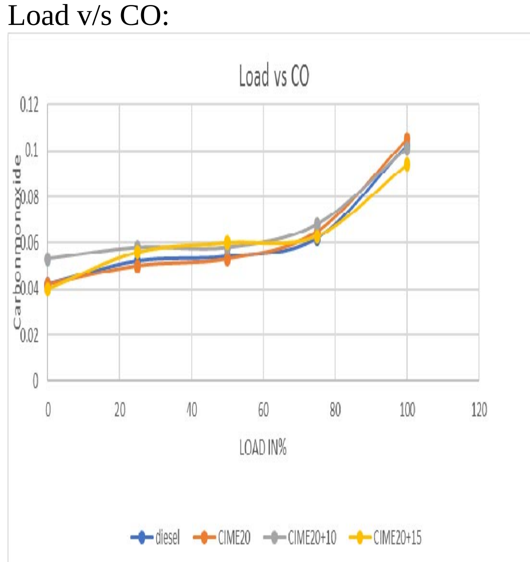

Fig.4.11 Load vs CO

CO emissions from the engine occur due to partial oxidation of the fuel mixture. The rate of CO formation is a function of unburned fuel and mixture temperature during combustion. The variation of CO emissions against brake power is shown in Fig.4.11 It is observed that CIME20+ISO15 has low emission of CO, at part load as compared with neat diesel. The CO emission is increased for higher loads.

Load v/s HC

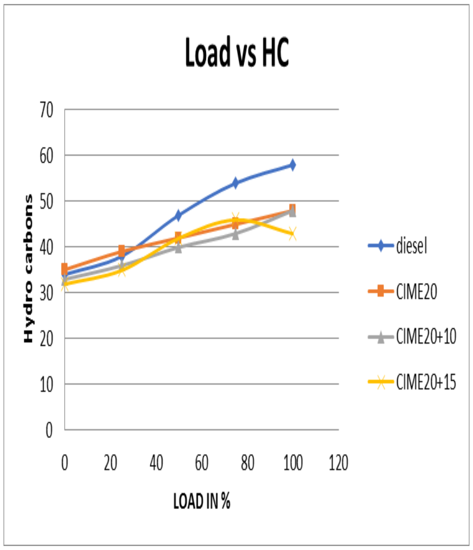

Fig. 4.13Load v/s HC diagram

The comparisons of hydrocarbon emissions for straight diesel, biodiesel are shown in Fig. While compared with base diesel, hydrocarbon emission was found in decreasing .

Rate in CIME20+ISO15.From the figure all the parameters has small variations .At full load condition CIME 20 has low hydrocarbon emission.

Load v/s NOx:

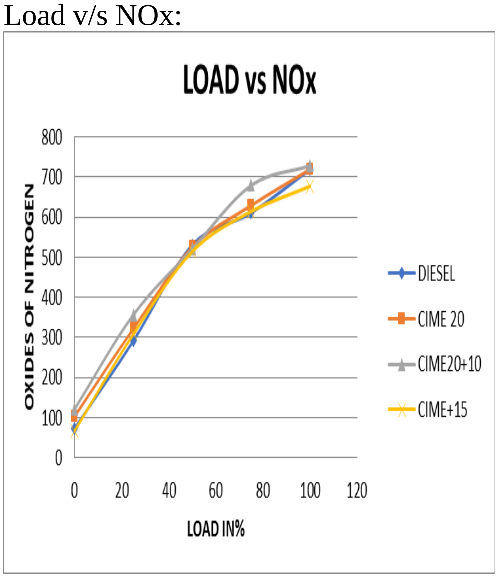

Fig.4.12 Load v/s NOx diagram

NOx formation rate depends upon in-cylinder gas temperature.NO x forms at high temperature burned gas regions. The comparison of variations of NOx emission with different blends substitution is shown in Fig.4.12 There is a reduction was observed in NOx emission up to part load levels. It is evident NOx is increased by increasing the load. This may due to reduction in fresh air in the combustion, which increases the ignition delay resulting into reduced cylinder peak pressure temperature. From the above graph diesel has low emission compared to the other blends.

V. CONCLUSION

The main objective of the present study was to use the non-edible calophyllum inophyllum oil as biodiesel in CI engine. To reduce the viscosity of neat calophyllum inophyllum, transesterification was done to bring it close to that of conventional diesel. In order to obtain a basis for comparison, Various blends are used such as (B10,B20,B30,B100) from this blends B20 shows best results compared to the diesel. To improve the performance characteristics Isobutanol additive added in the B20 in the concentration of 10% and 15%

Observations:

1. CIME20 gives the good performance and emission results in single cylinder operation
2. In CIME20 has low emission parameters except NOx and smoke emission compared to diesel engine operation.
3. The performance of CIME20 is further increased by adding Isobutanol additive.
4. Finally we conclude that by observing performance, combustion and emission analysis the combination of CIME20+ISO15 is acts like a diesel fuel with small deviations. At full load condition the CIME20+ISO15 will produce maximum B.P. so, this combination is recommendable for the stationary engine.

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