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Combustion Phenomena, Emissions and Performance Characteristics of Lemongrass Oil in Direct Injection (DI) Compression Ignition Diesel

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Abstract: Development of alternative fuels used in IC engines employ traditionally advance process which creates a fuel related issues, decisive fuel properties are indentified and their specific values are defined to solve problem. The present work deals with lemongrass oil (cymbopogon flexuosus) as an alternative fuel. By using trans-esterification process the lemongrass oil converted into biodiesel. This biodiesel is blended with the conventional diesel with various proportions and tests were conducted on 20%, 30% and 50% lemongrass oil blends with diesel. The performance characteristics, emissions and combustion phenomena are studied at 1500rpm of engine speed and compression ratio of 17.5 in a 4-stroke cycle mono cylinder DI compression ignition diesel engine. Comparison studies are made with conventional diesel fuel. Experimental outcomes revealed the successful ignition process in which the heat energy released from a DI compression ignition diesel engine fueled with lemon grass oil is within the limits.

***Index Terms*: Heat Energy Analysis, Ignition Analysis, Lemongrass Oil.**

I. INTRODUCTION

Climbing petroleum prices, increasing intimidation to the environment from exhaust emissions and global warming have generated penetrating international interest in developing the alternative non petroleum fuels for engines. A lot of research work is going on for an alternative fuel. One of the great potential alternative fuels is biodiesel which is produced from vegetable oil and animal fats. For long term, the usage of vegetable oils to produce biodiesel may compete with food supply and they are periodic and far too costly to be used as fuel at present. Energy deployment is obvious in every single human life. There are assented reasons opt for alternative fuels as a substitute of crude oil products. In detail, the energy insistence occurs due to two major arguments, first is the expeditions rise in the world wide populace and second is the utilization of the motors a considerable attention has been designated to use biodiesel as an alternative fuel for conveyance apparatus in order to label the challenges of augment diesel prices and fast exhaustion of nimbly accessible fossil fuel reserves [1-5]. In contemporary solar days, urbanized nations such as England, USA, Germany, France, Australia, and Newzeland and also emerging countries a like India, China, Malaysia and Indonesia ensure manifest their interest for escalating and fabricating in exhaustible energy fuels with certain government economic acids. Here, interest can be attributed to the often seen as cendancy of bio fuels, particularly a substantial fall of vehicle emissions. European countries have already commenced this auxiliary at sum percent for declining green house exhalation. In the year 2020 the European legislature would augment the bio fuel market share of about 15% and also, Canada government has suspected the avail of 7% heated biodiesel in the place of diesel in transportation sector by 2016 [6]. In genuine truth, a number of herb oils have been veteran (examine) all over the earth to evaluate their concert in diesel motors. While straight herb oil can be used as a solitary fuel, is a virulent accuracy a certain esterifies oil appearances superior fuel possessions [7,8]. This is due to certainty of herb oils reveal elevated viscosity than diesel and also a draw back on the utilize of biodiesel is its cost. In this worry an in eatable herb oil with closely resembling fuel possessions to diesel would urge an anomaly to do look in to coincidentally, lemongrass oil is one in the midst of those herb oils which shows authentically nearer possessions to ordinary diesel.

II. MATERIALS AND METHODS

In this investigation keeping in mind the end goals to know the impacts of lemongrass oil utilization in compression ignition motor, in barrel gas pressure follows was watched. Despite the fact that a top to bottom clarification of the ignition procedure in diesel engine is amazingly troublesome because of tremulous fluid jet occurrence and mixture of uneven certain helpful information to feature and clarity the burning characteristics of lemongrass oil was displayed in this exertion. This is finished with a guide of elevated determination information securing frame work. In this paper, an AVL burning analyzer attached with engine soft data acquisition system was used for burning analysis.

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The results from AVL compulsion transducer were transformed into electromotive force signs with the aid of charge enhance and its necessity of the AVL DI gas 444N and smoke meter are given in Table: 1a and 1b. At present attempt has been constructing to explore binary fuel concept. The fuel inoculated was exactly timed just succeeding the intake valve aperture in order to diminish the wall wetting concern. In this present work lemongrass oil blends were prepared in the ratio of LB20, LB30 and LB50. Fuel properties of lemongrass oil blends, neat lemongrass oil and unadulterated diesel are distinguished in Table: 2. Performance characteristics, emissions and combustion phenomena were tested on Kirloskar TV 1 model with eddy current type water cooled dynamometer loading; the results compared with unadulterated diesel fuel. The test engine specifications are given in Table: 3.

Table: 1 a Technical Specification of Exhaust Gas Analyzer

Emissions	Measurement Data	Resolution
CO	0-15% vol	0.01% vol
HC	0-30000 ppm	$\leq$ 2000:1 ppm vol >2000:10 ppm vol
CO_2	0-20% vol	0.01% vol
O_2	0-25% Vol	0.01% vol
NO_X	0-5000 ppm vol	1 ppm vol

Table: 1 b Technical Specifications of AVL 437C smoke meter

S.No.	Particulars	Specifications
1	Opacity measurement	0-100%, resolution 0.1%
2	Absorption	0-99.99m^{-1}
3	Accuracy and repeatability	$\pm$ 1% full scale
4	Colour temperature	3000 K $\pm$150 K
5	Heating time	20 min max. at 220v supply
6	Light source	Halogen lamp 12v/5W
7	detector	Selenium photocell diameter of 45 mm
8	Maximum smoke	250^0 C maximum at entrance
9	Measuring chamber	Length 430$\pm$ 5mm
10	Ambient operating condition	Temperature 0-50^0C, humidity 90% at 50^0C (non condensing)

Table: 2 Fuel Properties

Fuel Property	Unadulterated Diesel	Lemongrass Oil LB30	Neat Lemongrass Oil
Kinematic viscosity at 40 ^{0}C in Centi stokes	2.831	2.936	4.96
Flash point in ^{0}C	52^0C	51^0C	162^0C
Fire point in ^{0}C	58^0C	56^0C	171^0C
Gross calorific value kj/kg	42,500	38,390	33,238
Density in kg/m^3 at 15 ^{0}C	840	866	898

Table: 3 Test Engine Specifications

S.NO.	Particulars	Description
1	Engine type	Four stroke, single cylinder, vertical water cooled DI diesel engine.
2	Bore diameter	87.50 mm
3	Stroke length	110.00mm
4	Compression ratio	17.5:1
5	Rated power	5.20 kW
6	Speed	1500 rpm
7	Dynamometer	Eddy current type water cooled
8	Engine Make	Kirloskar, Model TV1

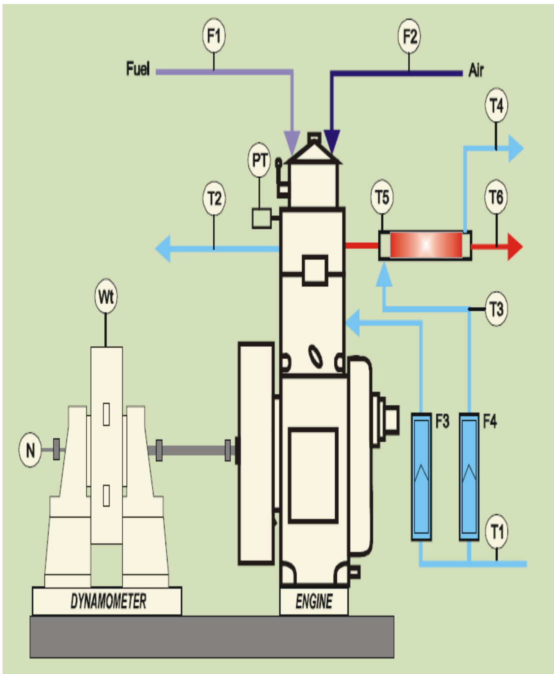

Figure: 1 Experimental Setup

F1= Fuel inlet
F2= Air inlet
F3= Rota meter for engine cooling water flow measurement
F4= Rota meter for calorimeter water flow measurement
T1= Engine cooling water inlet
T2= Engine cooling water outlet
T3= Calorimeter water inlet
T4= Calorimeter water outlet
T5= exhaust gas inlet
T6= Exhaust gas outlet
PT=Pressure transducer
WT= Eddy current type dynamometer for loading
N=crank angle encoder

III. RESULTS AND DISCUSSIONS

Performance Characteristics

A. Brake Thermal Efficiency

Figure: 2 demonstrates that the Brake thermal proficiency at different burdens. The brake thermal efficiency is increased in the blended lemongrass oil forLB20, LB30 and LB50 respectively when compared to unadulterated diesel is shown in plot. But for LB20 it was reduced at full load condition.

The high brake thermal efficiency for lemongrass oil compared to unadulterated diesel, this might be because of the existence of oxygen in lemongrass oil and the burning efficiency is increases, so the brake thermal efficiency is also increased.

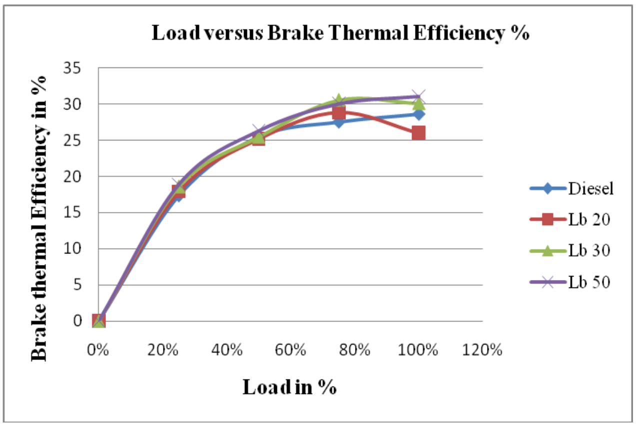

Figure: 2 Variations of Brake Thermal Efficiency and Load

B. Specific Fuel Consumption

Figure: 3 show the variation of specific fuel consumption with load. The graph shows a similar trend for all the loads of operation. For all the ratios, specific fuel consumption is increased while compared with unadulterated diesel fuel. This could be due to lower calorific value of higher ratios of lemongrass oil. But lower values of specific fuel consumption are desirable one.

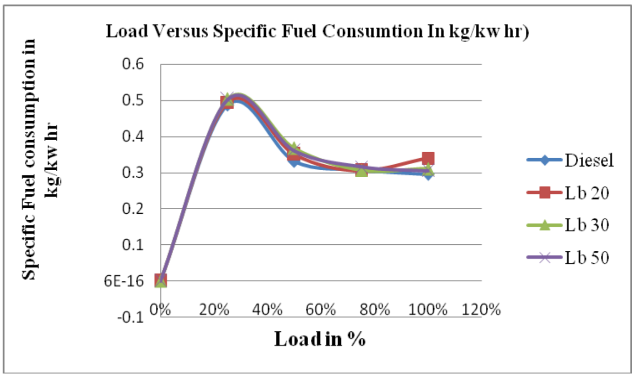

Figure: 3 Variations of Specific Fuel Consumption and Load

C. Indicated Thermal Efficiency

Figure: 4 show the variation of indicated thermal efficiency with load. The graph shows a similar trend for all loads of operation. For the entire blending ratio, the indicated thermal efficiencies are nearly equal to unadulterated diesel fuel except LB20 at full load indicated thermal efficiency is decreased when compared to unadulterated diesel. For LB 30 and LB 50 blends the indicated thermal efficiency is more when compared to unadulterated diesel. It could be the reason that high indicated mean effective pressure of lemongrass oil than unadulterated diesel.

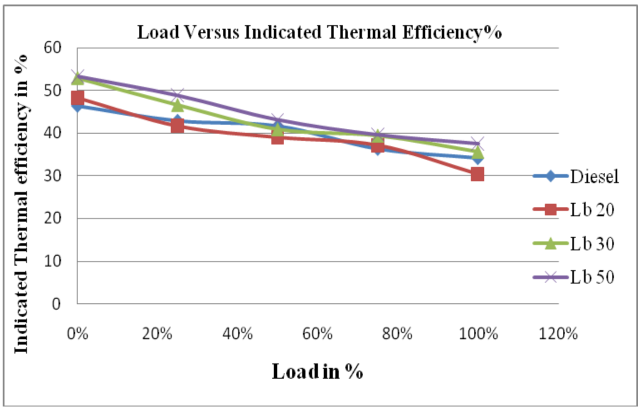

Figure: 4 Variations of Indicated Thermal Efficiency and Load

D. Mechanical Efficiency

Figure: 5 show the variation of mechanical efficiency for various ratios of lemongrass oil. For all the ratios, mechanical efficiencies are nearly closed values of diesel. As the load increases for unadulterated diesel and lemongrass oil blends LB20, LB30 and LB50, the mechanical efficiency is increased in trend and also very much closer to the unadulterated diesel is shown in plot. When related to blended lemongrass oil all the values of mechanical efficiency is very much nearer to the unadulterated diesel values. This could be the reason that brake power delivered by the engine was good and minimum frictional losses available in the engine.

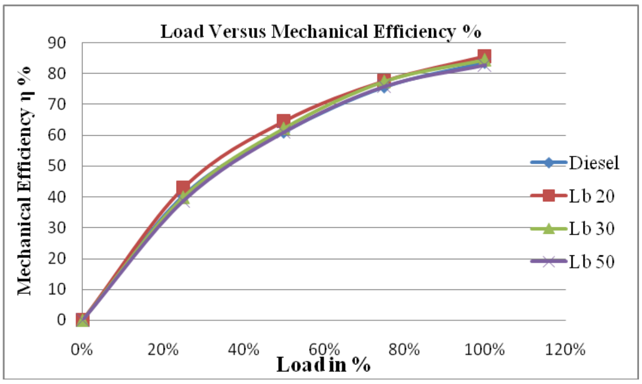

Figure: 5 Variations of Mechanical Efficiency and Load

E. Volumetric Efficiency

Figure: 6 shows that the variation of volumetric efficiency with load for different blends of lemongrass oil and unadulterated diesel. It was observed that the graph trends of lemongrass oil blends followed similar trend of unadulterated diesel. The volumetric efficiency of lemongrass oil was faintly less when compared to unadulterated diesel at full load. The reason for this fall in trends of lemongrass oil volumetric efficiency trends is that the viscosity of lemon grass oil is more when compared to unadulterated diesel.

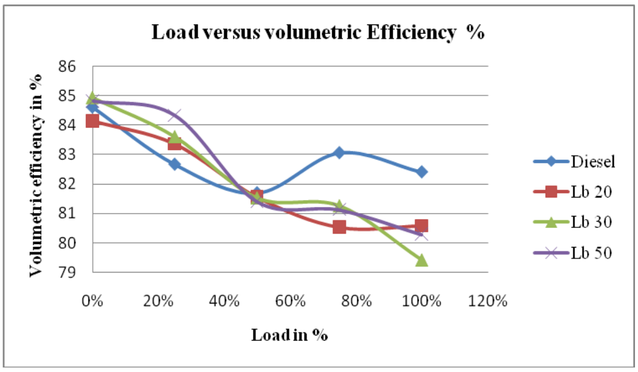

Figure: 6 Variations of Volumetric Efficiency and Load

Emission Characteristics

A. Effect of Fuel Blends/Load on Smoke Opacity

Figure: 7 demonstrated the smoke discharges of lemongrass oil- diesel mixes smoke darkness versus load. The smoke emissions of lemongrass oil –diesel mixes had comparative propensity as those of unadulterated diesel. The graph trends of smoke emissions of lemongrass oil blends are closer to the unadulterated diesel. At 75% load condition the smoke emissions are decreased for all blends but at full load condition the blends LB20 and LB30 smoke emissions are increased 6% and 6.4% respectively. This could be the reason of insufficient oxygen supply at full load.

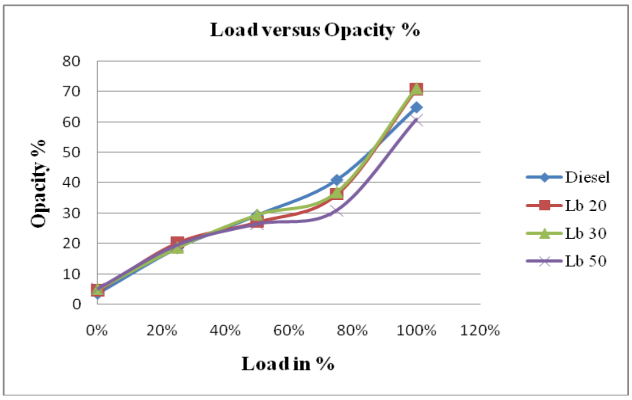

Figure: 7 Variations of Opacity and Load

B. Effect of Fuel Blends/Load on CO Emissions

Figure: 8 show the discrepancy of CO emission with load deviation. CO emission for LB50 is very close to unadulterated diesel fuel emission and it is found that at 25% and 50% load condition CO emissions was decreased for all lemon grass oil blends when compared to unadulterated diesel fuel. For LB20 and LB30, the CO emission is higher by 0.01% and 0.039% at full load state when related to unadulterated diesel. This might be reason of the scarcity of oxygen at high speed, and lesser time available for complete combustion and further rise in temperature in the combustion cavity, physical and chemical possessions of the fuel and also air-fuel ratio.

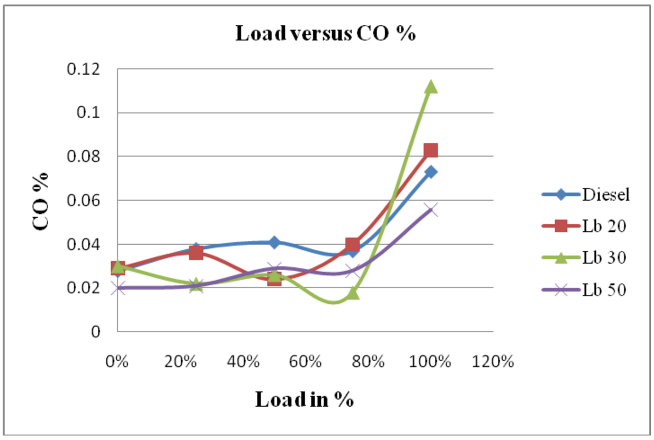

Figure: 8 Variations of CO and Load

C. Effect of Fuel Blends/Load on NO_x Emissions Analysis

The variation of NO_x emission with various ratios of lemongrass oil is shown in figure: 9. The graph trends are similar way of unadulterated diesel. It is observed that the NO_x emission is increasing trend than that of unadulterated diesel. The reason for higher NO_x emission could be due to higher peak flame temperature. The greatest gas temperature is the most vital factor of NO_x arrangement.

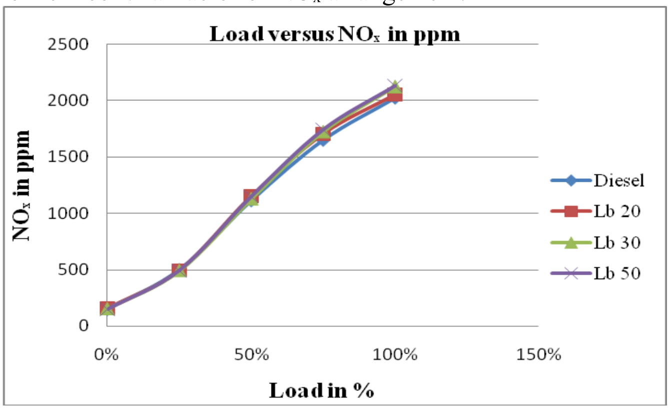

Figure: 9 Variations of NOx and Load

D. Effect of Fuel Blends/Load on CO_2 Emissions Analysis

Figure: 10 shows that the variation of CO_2 emission for lemongrass oil blends and unadulterated diesel with load variation. It can be observed that, up to 50% load all the lemongrass oil and diesel fuel blends ratios had lower CO_2 emissions when compared with unadulterated diesel and then increased with incremental of load. At 75% load and 100% load CO_2 emissions are increased. The higher CO_2 emissions indicates that, may be the complete combustion of fuel in the combustion chamber. The ratio for LB50 shows the lower CO_2 emissions at low loads it could be due to incomplete combustion and inadequate supply of oxygen for combustion process but increasing at higher loads.

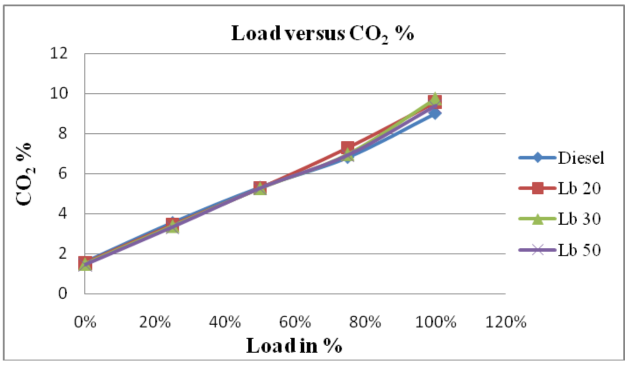

Figure: 10 Variations of CO_2 and Load

E. Effect of Fuel Blends/Load on O_2 Emissions Analysis

Figure: 11 shows that the variation of O_2emission for various ratios of lemongrass oil and unadulterated diesel. It can be observed that the variation of O_2 emission of lemongrass oil blends LB 20, LB 30 and LB 50 was very close to the unadulterated diesel except at 75% load and full load condition when it was compared. At 75% and full load condition, O_2 emission is high for unadulterated diesel. It could be the reason that the availability of more oxygen when combustion process was carried out so that better combustion may takes place.

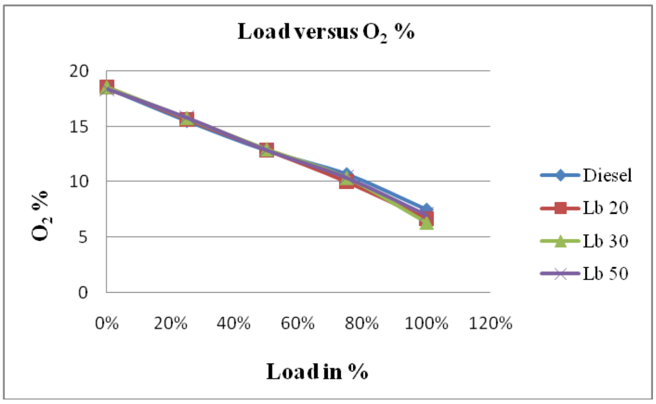

Figure: 11 Variations of O_2 and Load

F. Effect of Fuel Blends/Load on HC Emissions Analysis

The variation of hydrocarbon emission with unadulterated diesel and different ratios of lemongrass oil ratios is shown in Figure: 12. It shows that the HC emission of various ratios of lemongrass oil is lower than unadulterated diesel except for LB20. HC emission is higher by 2% for LB20 when compared with unadulterated diesel fuel. For all other lemongrass oil blends ratios, the HC emissions are lower than the diesel fuel due to the longer ignition delay and the accumulation of fuel in the combustion chamber.

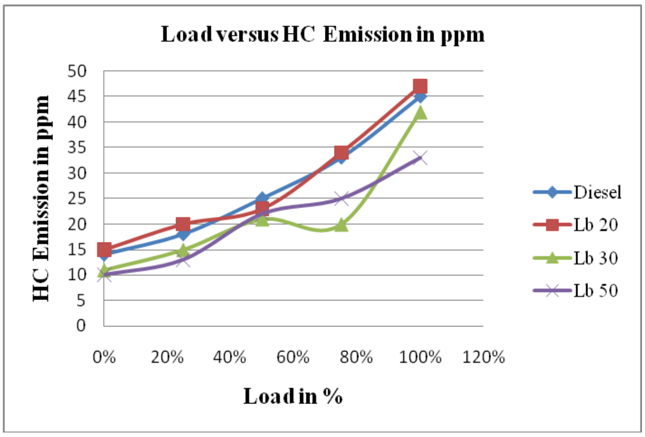

Figure: 12 Variations of HC and Load

Combustion Phenomena

A. Pressure Rise in Cylinder

As on figure 13 the variation of crank angle versus pressure in cylinder at 100% load. The peak pressure rise in cylinder obtained by diesel at 100% load condition. It was observed that pressure variation in cylinder versus crank angle is increased as the load increases for unadulterated diesel and blended lemongrass oil in the range of LB20, LB30 and LB50. The cylinder pressure rise is very much closer to the unadulterated diesel fuel is shown in plot. In the below plot the peak cylinder pressure obtained is higher for diesel (71.77bar) with sequent LB20 (70.38bar), LB30 (70.12bar) and LB50 (70.98bar) at full load condition. It owes by graph that the maximum cylinder pressure of unadulterated diesel is greater than the maximum cylinder pressure value obtained from the lemongrass oil blends. The motive for this abridged pressure is the lesser heating value and faintly higher viscosity of lemongrass oil related to unadulterated diesel.

A faintly burning rate is slow in lemongrass while combustion and due to enormous amount of energy released with subsequent of diesel is also cause.

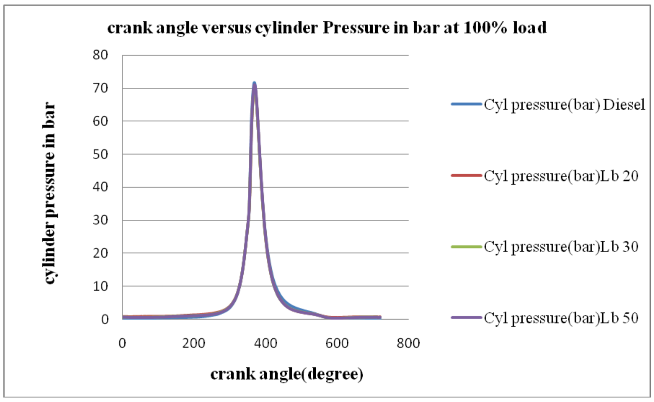

Figure: 13 Crank Angle versus Cylinder Pressure At 100% Load

B. Cylinder Pressure and Volume

The barrel compulsion pressure and consistent barrel volume during the motor operating sequence is plotted on a linear p-v diagram as shown in figure: 14.

It shows the succession of processes which make up a typical CI engine operating cycle fueled with unadulterated diesel and lemongrass oil blends LB20, LB30 and LB50 respectively. The sequence can be alienated into suction, compression, combustion, expansion and exhaust procedures. On the p-v diagram, one can understand that the surrounded area of diesel cycle is more when related to lemongrass oil blends. This bias evidently indicates that work per cycle is more for unadulterated diesel fuel procedure than lemongrass oil blends. It could be the reason for this bias is less warmth worth and slightly elevated viscosity of lemon grass oil blends when related to unadulterated diesel fuel. By that huge amount of energy might have out during the incineration of diesel than lemongrass oil blends.

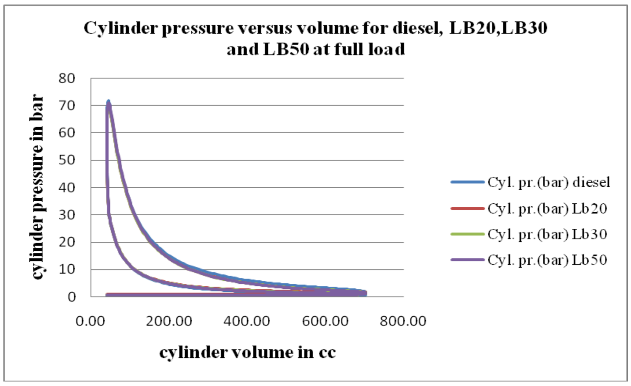

Figure: 14 Cylinder Pressure versus Volume for Diesel, LB20, LB30 and LB50 at Full Load

C. Net Heat Release

Figure: 15 shows the variation of net heat release with crank angle at full load condition for unadulterated diesel, LB 20, LB 30 and LB 50 respectively. It was observed that the peak net heat release for unadulterated diesel, LB20, LB30 and LB50 are 43.07kj, 38.65kj, 37.38kj and 36.93kj respectively at 100% load condition. It was observed that net heat release is increased when incremental of load percentage. The net heat release trends of lemongrass oil blends were followed similar way of unadulterated diesel when it was compared. The propellant experienced a hasty concoction burning accompany by scattering fire, as it is distinctive for naturally evoke engines. Succeeding the ignition interruption stretch, the concoction propellant air mixture burned hastily, liberating warmth at a immensely hasty rate, succeeding which scattering fire has been taken place. These appearances, the burning rate is managed by the accessible of inflammable propellant air mixture from the diagram it was detected that the warmth release rate is grater for diesel than lemongrass oil blends. This bias deceptively disclose that the rate of compulsion rise is proportionate to the rate of warmth liberate.

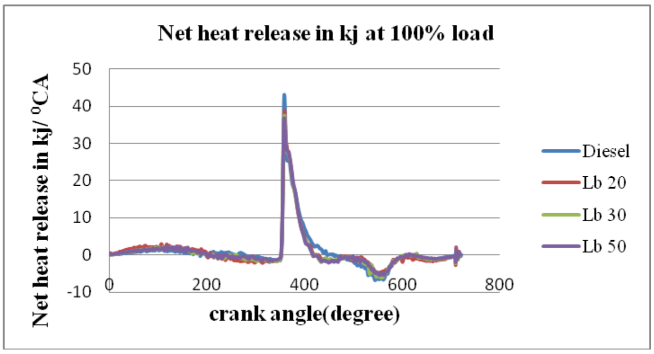

Figure: 15 Net Heat Release versus Crank Angle in At100% Load

D. Mass Fraction Burned

Figure: 16 Shows the mass fraction burned. The trend has S-shape characteristic. From the graph, the rate at which fuel-air mixture burns rises from zero (start of combustion) and then trends exponentially to one (end of combustion). In the below figure it was observed that the fuel air mixture of various blends of lemongrass oil was burned mostly similar way of fuel-air mixture of unadulterated diesel fuel. The graph trend is very close to unadulterated diesel. It could be the reason that fuel-air mixture of lemongrass oil is burned completely in the combustion chamber.

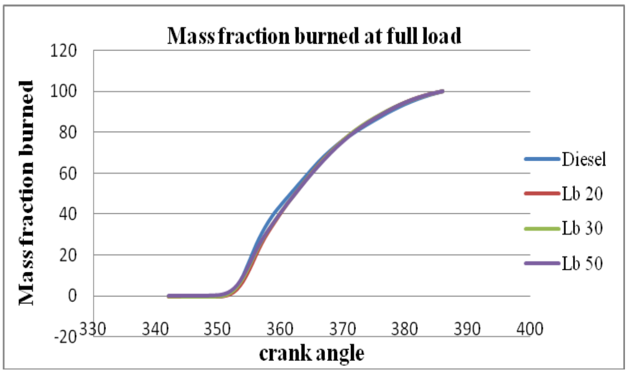

Figure: 16 Mass Fractions Burned Versus Crank Angle at Full Load

IV. CONCLUSIONS

Combustion Phenomena, Emissions and Performance Characteristics of Lemongrass Oil in Direct Injection (DI) Compression Ignition Diesel Engine fuelled with unadulterated diesel and lemongrass oil blends LB20, LB30 and LB50 have been investigated and compared with unadulterated diesel fuel. From the above investigation following conclusions were drawn.

1. The brake thermal proficiency is high in lemongrass oil related to unadulterated diesel.
2. For lemongrass oil, SFC is increased when related to unadulterated diesel operation due to lower calorific value of higher ratios of lemongrass oil. But lower values of SFC are desirable one.
3. Mechanical efficiency is increased as the load increases for lemongrass oil blends as compared to unadulterated diesel.
4. The Indicated thermal efficiencies are nearly equal to unadulterated diesel fuel.

5. The smoke emissions of lemongrass oil blends are closer to the unadulterated diesel but at full load condition the blends LB20 and LB30 smoke emissions are increased 6% and 6.4% individually.

6. CO emission for LB50 is very close to unadulterated diesel fuel emission and it is found that for LB20 and LB30, the CO emission is higher at full load when compared with unadulterated diesel fuel.

7. It is observed that the NO_x emission is increasing trend than that of unadulterated diesel. The reason for higher NO_x emission could be due to higher peak flame temperature.

8. For CO2 emission, up to 50% load all the lemongrass oil and diesel fuel blends ratios had lower CO2 emissions when compared with unadulterated diesel and then increased with increase of load.

9. Hydrocarbon (HC) emission of various ratios is lower than unadulterated diesel except for LB20. Hydrocarbon (HC) emission is higher by 2% for LB20 when compared with unadulterated diesel fuel.

10. From the graph the maximum pressure rise in cylinder of unadulterated diesel is higher than the maximum cylinder pressure value attained from lemongrass oil blends. The maximum cylinder pressure of lemongrass oil blends is comparatively less when compare to the maximum cylinder pressure of unadulterated diesel at the same operating conditions.

11. It was observed that the heat release rate is lower for lemon grass oil blends than unadulterated diesel. This trend deceptively discloses that the rate of pressure rise is impartial to the rate of heat release.

12. Sciatic progresses are vitally essential in current engine technology to address the global concern on exhaustion of easily available fossil fuels.

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