PERFOMANCE AND EMISSION TEST OF SINGLE CYLINDER DIESEL ENGINE (CRDI) USING LEMON PEEL OIL

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BONAFIDE CERTIFICATE

Certified that this project title **PERFOMANCE AND EMISSION TEST OF SINGLE CYLINDER DIESEL ENGINE (CRDI) USING LEMON PEEL OIL** is the bonafide work of

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Who carried out the design project under my supervision Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ஆய்வுச்சுருக்கம்

வழக்கமான பெட்ரோலிய வளங்களை பற்றாக்குறையாக மற்றும் துரிதமாக சீரழிக்கப்படுவதானது, உள்ளக எரிப்பு இயந்திரங்களுக்கான மாற்று எரிபொருட்களுக்கான ஆராய்ச்சிகளை ஊக்குவித்தது. பல்வேறு சாத்தியமான விருப்பங்கள் மத்தியில், தாவர எண்ணெய்கள்/விலங்கு கொழுப்புகள் இருந்து பெறப்பட்ட எரிபொருள்கள் ' ' கிரீன்வர் ' ' புதைபடிவ எரிபொருள்களுக்கு பதிலாக ' '. தாவர எண்ணெய்கள் வளிமண்டலத்தில் உள்ள நிகர CO2 உமிழ்வுகளை, பெட்ரோலியப் பொருட்களின் இறக்குமதிப் பதிலீடு செய்வதன் மூலம் குறைக்க முடியும். எனவே, எஞ்சின் செயல்திறனை மேம்படுத்த, நெரித்தழுத்தல் இக்னிஷன் (CI) என்ஜின்களில் இருந்து எரிதல் மற்றும் கட்டுப்படுத்துதல், நாம் பொதுவான ரயில் நேரடி ஊசி (CRDI) தொழில்நுட்பத்தைப் பயன்படுத்துகிறோம் ஃபியூவல் இன்ஜெக்ஷன் அளவுருக்கள், ஊசி (SOI) டைமிங், ஃபியூவல் இன்ஜெக்ஷன் மற்றும் ஊசி செலுத்தப்பட்ட கால அளவு ஆகியவற்றை கட்டுப்படுத்துவதன் மூலம் வரம்பற்ற சாத்தியக்கூறுகளை வழங்குகிறது. எரிபொருள் எரிபொருளின் அழுத்தம் 1500 rpm இல் 400 பொருட்டல்ல அமைக்கப்படுகிறது. லெமன் பீல் டீசல் பல்வேறு விகிதத்திலும், செயல்திறனிலும், புகை வெளியேற்றத்திலும் கலப்புகிறது.

ABSTRACT

The scarce and rapidly depleting conventional petroleum resources have promoted research for alternative fuels for internal combustion engines. Among various possible options, fuels derived from vegetable oils/animal fats present promising "greener" substitutes for fossil fuels. Vegetable oils are able to reduce net CO2 emissions to the atmosphere along with import substitution of petroleum products. So, to improving engine performance, combustion and controlling emissions from compression ignition (CI) engines, we use common rail direct injection (CRDI) technology offers limitless possibilities by controlling fuel injection parameters such as fuel injection pressure, start of injection (SOI) timing, rate of fuel injection and injection duration. The pressure of the fuel ignition is been set as 400 bar at 1500 rpm. The lemon peel diesel is blend at the Various ratio and performance and emission are carried out.

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INTRODUCTION

1. INTRODUCTION

Diesel engines have provided power units for road transportation systems, ships, railway locomotives, equipment used for farming, construction, and in almost every type of industry due to its fuel efficiency and durability. However, Diesel engines are the major sources of NOx and particulate matter emissions which are environmental concerns. For automotive industry the reduction of NOx admission is the most important task. National government superimposing stringent emissions. Therefore, the stringent emission regulation requirements give a major challenge to comply emission targets while maintaining its performance, drivability, durability, and fuel economy. The use of alternative fuels for internal combustion engines has attracted a great deal of attention due to fossil fuel crisis and also GHG impact.

A large segment of modern transportation systems is powered by direct injection diesel engines. This is due to numerous advantages offered by these combustion systems in terms of excellent. fuel economy and higher power density compared to indirect injection systems as well as spark ignited gasoline engines. Increasing the fuel injection pressures and optimizing the injection strategies are extremely important for further improvements in highly optimized compression ignition (CI)engines. The flexibility to change the injection strategy and multiple injection capabilities are not offered by mechanical fuel injection systems. On the other hand, in electronic fuel injection systems, fuel injection parameters such as injection pressure, fuel injection rate, multiple injections and the start of injection (SOI) are precisely controlled and regulated with great ease by an electronic control unit (ECU) under different engine operating conditions

One of the promising alternative fuel considered for diesel engines is diesel. Diesel fuels are renewable, as the carbon released by the burning of diesel fuel is used when the oil crops undergo photosynthesis. Biodiesel also offers the advantage of being able to readily use in existing diesel engines without engine modifications. Even though diesel has many advantages, because of engine problems its use is restricted to maximum 20.

2. LITERATURE SURVEY

SL.NO	AUTHOR	JOURNALS NAME	PUBLISHED YEAR	USING OIL	TESTING	RESULTS
1.	Sneh Guptha, Charu Guptha	Comparative study of antimicrobial effect of lemon oil and peel extract against food spoilage microbes	Oct 11,2017	Lemon oil	Lemon peel oil extract spoiled foods	Isolated from the spoiled food products
2.	Junab Ali, Biswajit Das, Trideep Sakia	Antimicrobial activity of lemon peel (citrus lemon) extract	Apr 20,2017	Lemon peel (citrus lemon)	Antimicrobial activity of ethanol and methanol ratio	phytochemical analysis
3.	Alholy Hendry Henderson, Edy Fachcial, I. Nyoman Ehrich ter	Antimicrobial activity of lemon peel extract against Escherichia coli	May 19,2016	Citrus lemon peel, Escherichia coli, antimicrobial	Lemon and orange-peel extract	Lemon peel with extracted with ethanol 96%

SL.NO	AUTHOR	JOURNALS NAME	PUBLISHED YEAR	USING OIL	TESTING	RESULTS
4.	**R. Vallinayagam, S. Vedharaj, W. M. Yang, P. S. Lee, K. J. E. Chua and S. K. Chou,**	**Lemon Essential oil – A Partial Substitute for Petroleum Diesel Fuel in Compression Ignition Engine**	**Oct,2014**	**Biofuel, lemon essential oil.**	**“Combustion performance and emission characteristics study of pine oil in a diesel engine”.**	**Diesel engine operated at different loading condition varied from zero load, 25% to 100**
5.	**S. A. Ahmed, S. Prabhakar, B. K. Solmon and M. I. Ahmed,**	**lemon peel extract against Escherichia coli with diesel engine**	**March,2015**	**Lemon peel and antimicrobial oils.**	**“Performance test for lemon grass oil in twin cylinder diesel engine”.**	**Lemon peel with extracted with ethanol 85%.**
6.	**J. Sun, J. A. Caton and T. J. Jacobs,**	**Antimicrobial activity of lemon peel (citrus lemon)**	**Oct 2,2015**	**Lemon peel oil and vegetable oil**	**“Oxides of nitrogen emissions from biodiesel-fuelled diesel engines”. Progress in Energy and Combustion**	**Lemon peel with extracted with ethanol 75%**

SL.NO	AUTHOR	JOURNALS NAME	PUBLISHED YEAR	USING OIL	TESTING	RESULTS
7.	**M.H. Ahamed, Abd, E.I. Ghafer M.Ibrahim, A.A Abdul Fattach**	**Peels of lemon and orange as value added ingredients chemical and antioxidant properties**	**Nov 28,2016**	**Lemon and orange-peel oil**	**Chemical analysis**	**Lemon peel and orange-peel extract with ethanol and methanol**
8.	**L. Rozza, T. de Mello Moraes, H. Kushima, A. Animator, M. O. M. Marques, T.M. Bauab and C. H. Pellizzon**	**Peels of lemon and orange as value added ingredients chemical's for C.I engine's**	**May 4,2013**	**Lemon peel oil's**	**Gastroprotective mechanisms of Citrus lemon (Rutaceae) essential oil and its majority compounds limonene**	**Lemon peel oils with extracted with methanol 80%**

9.	**M. Gumus and S. Kasifoglu,**	**Lemon Essential oil – A Partial Substitute for Diesel Fuel in Ignition Engine**	**Mar 5,2017**	**Lemon peel and seed oil’s.**	**A nonconventional method to extract D-limonene from waste lemon peels and comparison with traditional Soxhlet extraction.**	**The combustion process of any alternative fuels can be analysed and investigated by calculating the HRR**
10.	**G. Lopresto, F. Petrillo, A. A. Casazza, B. Aliakbarian, P. Perego and V. Calabr**	**lemon peel extract against Escherichia coli**	**Jun 3,2014**	**Lemon peel oil’s.**	**Performance and emission evaluation of a compression ignition engine using a biodiesel**	**Diesel engine operated at different loading condition varied from zero load, 25% to 100% for both the diesel and LEO20 fuels**

3. EXPERIMENTAL SETUP AND EXPERIMENTS

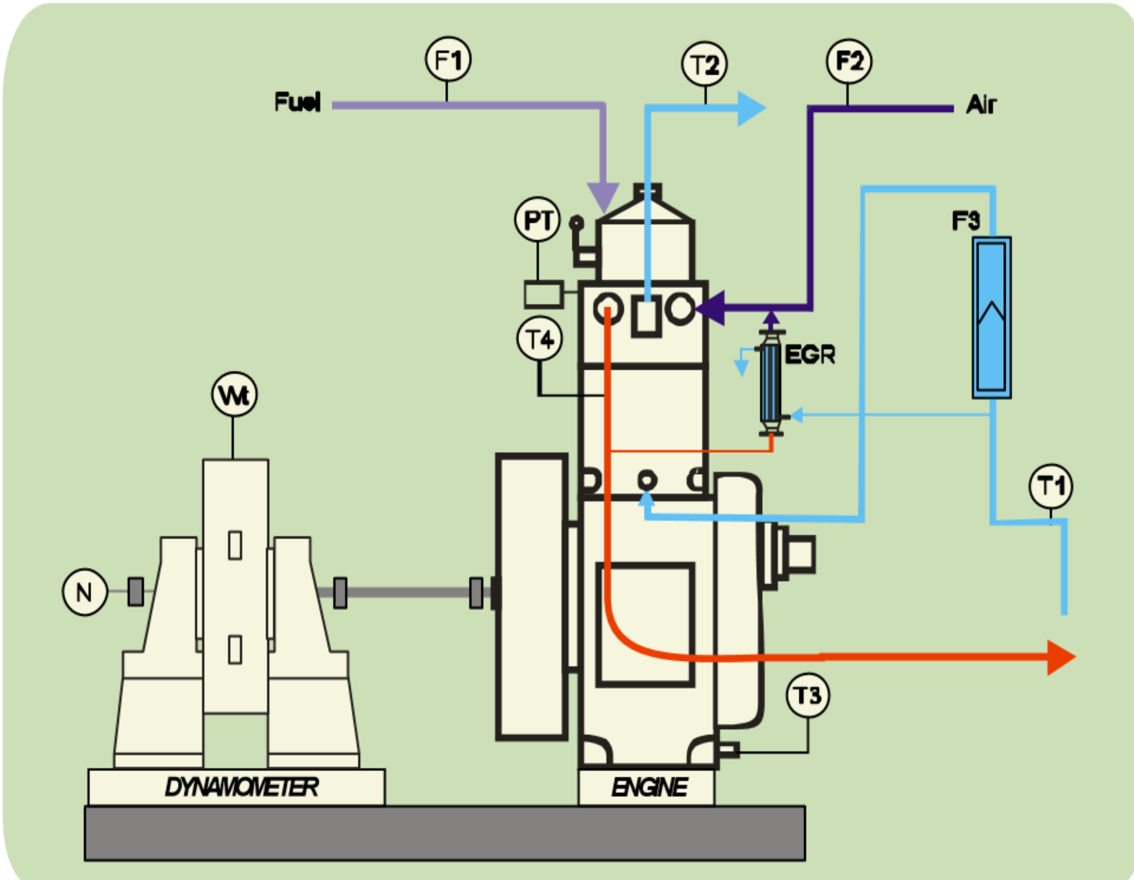
A typical 3.5kW single-cylinder 4-stroke water-cooled diesel engine at 1500rpm was used for the research work, and Table 2 presents engine specifications. The schematic diagram of the experimental set up is shown in Figure1. An eddy current dynamometer was used for load control on the engine. The piezoelectric pressure transducer was mounted on cylinder head. Various thermocouple temperature sensors were installed at appropriate locations to measure water inlet and outlet, manifold air temperature, exhaust outlet, and heat exchanger outlet temperatures.

A temperature thermocouple was installed on the surface of high-pressure fuel pipe. A precision crank angle encoder was coupled with the main shaft of the engine. Two openings were made in exhaust gas pipeline for sampling purposes. Fuel metering was done using a burette fitted with a three-way valve measuring unit installed on fuel tank as shown in Figure1.

The mass flow rate of intake air was measured with an orifice meter connected to a manometer. A surge tank was used to damp out the pulsations produced by the engine, for ensuring a steady flow of air through the intake manifold. An AVL 444 Di gas analyzer was used for measuring the CO, HC, and NO x emissions and the smoke density was measured using AVL437 smoke meter.

The engine was warmed up prior to data acquisition. All the engine test runs were carried out in fair constant ambient conditions. During the tests with Jatropha biodiesel, the engine was started with diesel until it was warmed up and then fuel was switched to various diesel-biodiesel blends. After finishing the tests with diesel-biodiesel blends, the engine was always switched back to diesel fuel and the engine was run until the biodiesel had been purged from the fuel line, injection pump, and injector.

3.1 EXPERIMENTAL SETUP



The engine was warmed up prior to data acquisition. All the engine test runs were carried out in fair constant ambient conditions. During the tests with lemon peel oil diesel, the engine was started with diesel until it was warmed up and then fuel was switched to various diesel blends. After finishing the tests with lemon peel oil-diesel blends, the engine was always switched back to diesel fuel and the engine was run until the diesel had been purged from the fuel line, injection pump, and injector.

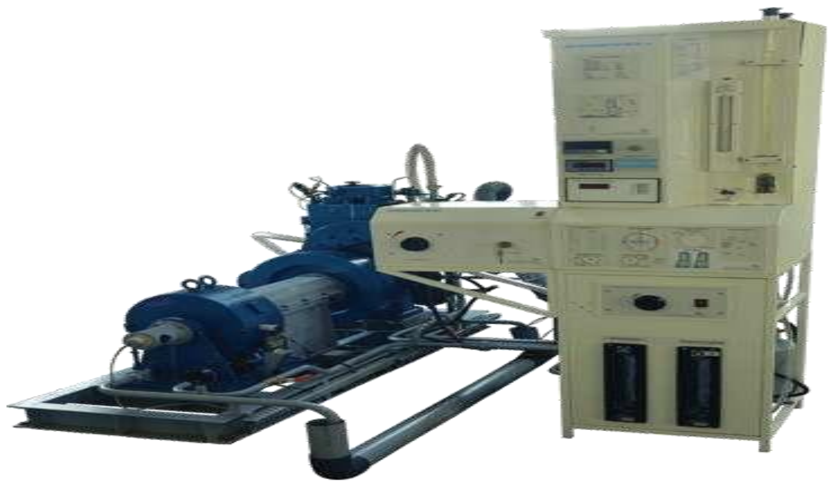
At every operation the engine speed was checked and maintained constant. All the measurements were repeated five times, and the arithmetic mean of these five readings was employed for calculation and analysis.

The different performance and emission parameters analyzed in the present investigation were brake thermal efficiency (BTE), brake specific fuel consumption (BSFC), exhaust gas temperature (EGT), carbon monoxide (CO), unburned hydrocarbons (UHC), nitrogen oxides (NOx), and smoke opacity. Then compression ratio was taken as 16,17.5 & 19 and fuel injection pressure was 400 bar.

METHODOLOGY

4. METHODOLOGY

4.1. STUDY OF DIESEL ENGINE



The setup consists of single cylinder, four stroke, CRDI VCR (Variable Compression Ratio) engine connected to eddy current dynamometer. It is provided with necessary instruments for combustion pressure, crank angle, airflow, fuel flow, temperatures and load measurements. These signals are interfaced to computer through high speed data acquisition device. The setup has stand-alone panel box consisting of air box, twin fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and piezo powering unit.Rotameter are provided for engine cooling water flow measurement. CRDI VCR engine works with programmable Open ECU for Diesel injection, fuel injector, and common rail with rail pressure sensor and pressure regulating valve, crank position sensor, fuel pump and wiring harness. The setup enables study of CRDI VCR engine performance with programmable ECU at different compression ratios and with different EGR. Engine performance study includes brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, Air fuel ratio, heat balance and combustion analysis.

FEATURES:

Online measurements and performance analysis • PΘ-PV plots, performance plots and tabulated results • Data logging, editing, printing and export • Configurable graphs

IP, IMEP, FP indication • Combustion analysis • Valve timing diagram study

RANGE OF EXPERIMENTS:

• Study of engine performance (Manual mode)
• Study of engine performance (Computerized mode)
• Study of pressure volume plot and indicated power
• Study of valve timing diagram

SOFTWARE:

Engine Soft is Lab VIEW based software package developed by Apex Innovations Pvt. Ltd. for engine performance monitoring system. Engine Soft can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. The software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine set up. Various graphs are obtained at different operating condition. While on line testing of the engine in RUN mode necessary signals are scanned, stored and presented in graph. Stored data file is accessed to view the data graphical and tabular formats. The results and graphs can be printed. The data in excel format can be used for further analysis.

4.2. CRDI ENGINE SPECIFICATION

Product	CRDI VCR Engine test (Computerized) Code 244
Engine	Make Kirloskar, Single cylinder, 4 strokes, water cooled, stroke 110 mm, bore 87.5 mm, 661 cc. Power 3.5 KW, 1500 rpm, CR range 12-18.
Dynamometer	Type eddy current, water cooled with loading unit
Propeller shaft	Make Hindustan Hardy, with universal joints
ECU	Model Naira i7r (with solenoid injector driver) with programmable ECU software and Calibration cable
Common rail	With pressure sensor and pressure regulating valve
EGR	SS, Water cooled
Injector	Type solenoid driven
Piezo sensor	Make PCB USA, Combustion: Range 350Bar with low noise cable
Crank angle sen	Make Kubler Germany, Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	Make NI Instrument USA, NI USB-6210, 16-bit, 250kS/s.
Temperature sensor	Make Radix, Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	Make ABUSTEK USA, Type two wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type two wire, Input Thermocouple,
Load sensor	Make VPG Centronics, Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	Make Yokogawa Japan, DP transmitter, Range 0-500 mm WC
Fuel tank	Capacity 15 lit, Type: Duel compartment, with fuel metering pipe of glass
Air flow transmitter	Make Wike Germany, Pressure transmitter, Range (-) 250 mm WC
Air box	M S fabricated with orifice meter and manometer Software
Software	“Engine soft” Engine performance analysis software
Rotameter	Make Eureka, Engine cooling 40-400 LPH

Open ECU

- Closed loop control for idle RPM
- Demand speed control
- Closed loop fuel pressure control
- Start control
- Pilot injection
- Separation control among pilot injection
- Injection timing control
- Engine Performance optimization Software.
-

CRANK TRIGGER WHEEL

Crank trigger wheel with trigger sensor

CRANK SENSOR

A crank sensor is an electronic device used in an internal combustion engine, both petrol and diesel, to monitor the position or rotational speed of the crankshaft. This information is used by engine managements system to control fuel injection of ignition system timing and other engine parameters. Crank sensor can be used in a combination with a similar camshaft position center to monitor relationship between pistons and valves in engine. It is commonly used as the primary source for the measurement of engine speed in revolutions per minute.

PERFORMANCE OF THE ENGINE

ENGINE DETAILS:

IC Engine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is 1 Cylinder, four stroke, Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 16.00, Swept volume 661.45 (cc)

COMBUSTION PARAMETERS:

Specific Gas Const (kJ/kg.): 1.00, Air Density (kg/m^3): 1.17, Adiabatic Index: 1.41, Polytrophic Index: 1.31, Number of Cycles: 10, Cylinder Pressure, Smoothing 2, TDC.

PERFORMANCE PARAMETERS:

Orifice Diameter (mm): 20.00, Orifice Coif. Of Discharge: 0.60, Dynamometer Arm Length (mm): 185, Fuel Pipe dia (mm): 12.40, Ambient Temp. (Deg C): 27, Pulses Per revolution: 360, Fuel Type: Diesel, Fuel Density (Kg/m^3): 860, Calorific Value of Fuel (kJ. /kg): 41540

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC):

Brake Specific fuel consumption (BSFC) or sometimes simply Brake specific fuel consumption, BSFC, is an engineering term that is used to describe the fuel efficiency of an engine design with respect to thrust output. Brake Specific Fuel Consumption may also be thought of as fuel consumption generally in grams/sec.

BRAKE THERMAL EFFICIENCY:

Brake Thermal Efficiency is defined as brake power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy.

4.3 BIO -DIESEL

4.3.1 INTRODUCTION TO BIO- DIESEL

Diesel is an alternative fuel consisting of the alkyl monoesters of fatty acids derived from vegetable oils and animal fats. It has been the focus of a considerable amount of recent research because it is renewable and reduces the emission of some pollutants. In Europe, rapeseed oil-based esters have been widely used as an alternative diesel fuel.

A number of researchers have investigated vegetable oil-based fuels. Most have concluded that vegetable oils can be safely burned for short periods of time in a diesel engine. However, using raw vegetable oil in a diesel engine for extended periods of time may result in severe engine deposits, injector coking, and thickening of the lubricating oil. The high viscosity of raw oil reduces fuel atomization and increases fuel spray Penetration.

4.3.2 NEED FOR DIESEL AND LEMON PEEL OIL

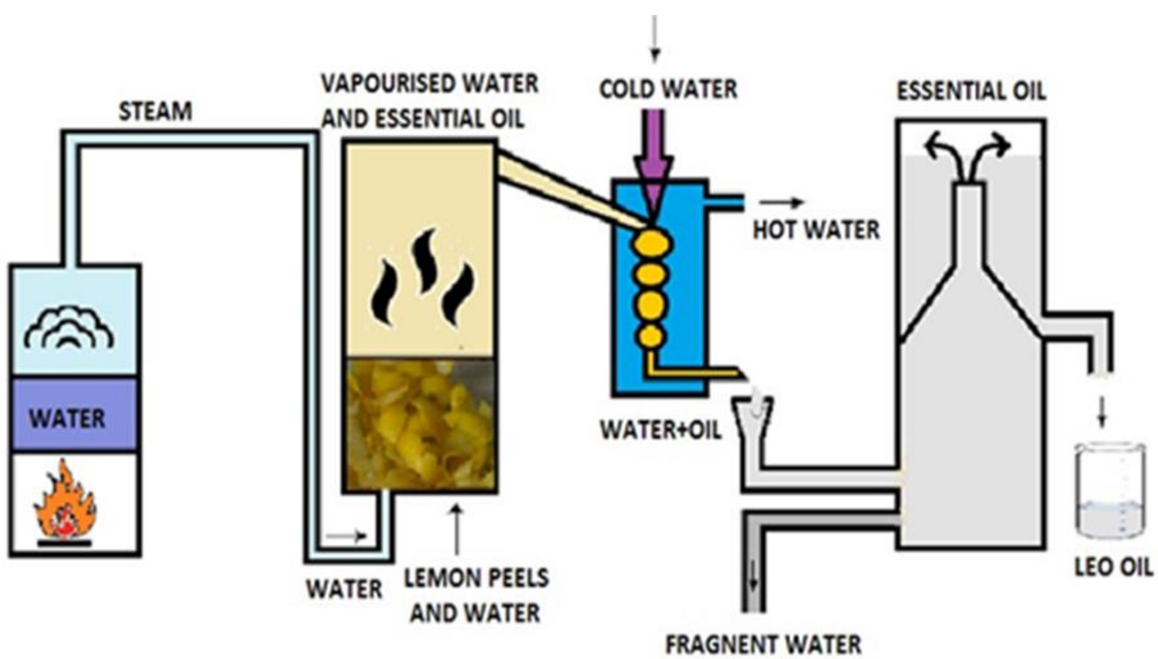
Due to the increase in price of petroleum and environmental concern about pollution coming from automobile emission, biodiesel is an emerging as developing area of high concern. The world is confronted with the twin crises of fossil fuel depletion and environmental degradation. Alternative fuels, promise to harmonize sustainable development, management, energy conversion, environmental preservation and efficiency. Vegetable oil is a promising alternative to petroleum products. The economic feasibility of biodiesel depends on the price of crude petroleum and the cost of transporting diesel over long distances to remote areas.

It is a fact that the cost of diesel will increase in future owing to increase in its demand and limited supply. A great deal of research and development on internal combustion engines has taken place not only in the design area but also in finding an appropriate fuel. Many researchers have concluded that biodiesel holds promise as a perfect alternative fuel for diesel engines, since biodiesel properties are very close to diesel. The fuel properties of biodiesel such as cetane number, gravity, heat of combustion, and viscosity influence the combustion and so the engine performance and emission characteristics because it has different physical and chemical properties than petroleum-based diesel fuel.

4.3.3 LEMON ESSENTIAL OIL PREPARATION

Steam distillation technique is accomplished in this work for the extraction of lemon essential oil (LEO) from the rinds of lemon. This method is one of the pioneer techniques that are being utilized as a part of the extraction of fundamental oils. The schematic setup of the steam distillation process is shown in Fig.1 and this process involves the flow of steam into the chamber which consists of lemon rinds (peel).

Lemon peels are taken in to a distillation chamber that has boiling water which produces an enormous amount of steam and this steam is evaporated to a condensing chamber. The water vapour and oil obtained from boiling chamber is brought to condensing chamber via spiral tube. This chamber is supplied with constant flow of cooled water. Cold water supply is kept constant as it condenses the vapour as it passes out of the chamber. The condensed material is made to exit the chamber and it gets collected in a separate chamber that is similar to that of a separating funnel. In the new chamber the separation process is carried out, where oil and water are collected at different points. The oil thus obtained is the lemon essential oil and quality of the distilled oil is depending on various factors such as duration of the process, temperature, pressure and refining equipment nature.



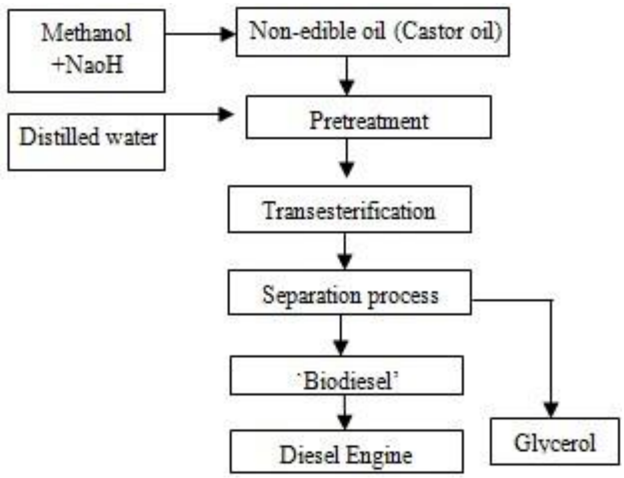
4.3.4 AVAILABLITY OF LEMON PEEL OIL

India has rich and abundant resources of both edible and non-edible oil seeds. The production of methyl/ethyl esters from non-edible oils is much more expensive than that of diesel fuels. This is due to the relatively high costs of vegetable oils (about four times the cost of diesel in India).Therefore there is a need to search and explore alternate feed stocks for the production of biodiesels. Non-edible oils from sources such as honge, lemon peel are easily available in many parts of India and are cheap compared to edible oil. Lemon peel extract is a large shrub or tree commonly found throughout most of the tropical and sub-tropical regions of the world. The citrus plant is a drought-resistant, perennial plant living up to 50 years and has the capability to grow on marginal soils. Lemon peel oil is extracted From lemon peel and need seed. Lemon peel is widely used in the extraction process instead of neem leaf as the oil content is found to be more in peels.

It requires very little irrigation and grows in all types of soils. The production of lemon peel is about 0.8 kg/m2per year. The oil content of lemon peel ranges from 30–40% by weight and the kernel itself ranges from 45% to 60%. Fresh lemon peel is a slow drying, odorless and colorless oil, and turns yellow after aging.

4.3.5PROCEDURE FOR PREPARATION OF BIODIESEL

The vegetable oils and fats are made up mainly of triglycerides. When, these triglycerides react chemically with alcohols in presence of a catalyst (base/acid) result in fatty acid esters. This methyl esters show striking similarity to petroleum derived diesel and are called "Biodiesel". Biodiesel is produced by transesterification of oil obtains from the peels.



In the preparation of biodiesel five distinct stages will be involved,

1)Heating of oil.

2)Preparation of alkaline mixture.

3)Adding of alkaline alcohol to oil and stirring the mixture.

4)Settling of separation of glycerol.

5)Washing of ethyl ester with water

4.3.6 BLENDING OF BIO-DIESEL

Bio blend fuels produce and sell 100% Bio – diesel (B100) manufacture from the raw materials by a process called transesterification. However, unblended Diesel is problematic in that it tends to gel at a Temperature of 32F or below. For this reason, Bio-diesel sold for using private vehicles is usually blended with petrol, Diesel, a common blend being 20% Bio-Diesel to 80 % Diesel mixing and 30% Bio-diesel to 70%diesel.

A B20 blend gels are around 70F, a full 15 degrees below freezing and ends is much more reliable. Commercial users and the other hand, such as operators of farm vehicles, are better able to be deal with the short comings of B100. Appropriate planning and may still wish to take advantage of the thrice difference. Bio blend fuels are selling B100 at significantly below the National average cost of Diesel. Other groups of users may wish to reach a different compromise with a different blend.

4.3.7 RAW MATERIALS FOR BLENDING

A number of sources are used in the production of Diesel, including the more additional vegetable oils. However, much publicity surrounded Diesel this is a to sources is main ingredient from big fat. This is largely obtained from its rendering plants to are producing cooked pacon from pork in microwave ovens.

Amongst the claimed advantage of lemon peel oil blends Diesel is that it has a sweeter smell then regular Bio-Diesel. The product smells of pacon, unlike regular Bio-Diesel, describe by one reviewer as smelling of “Rancid popcorn”.

4.3.8 PROPERTIES OF LEMON PEEL OIL

Fuel properties diesel and lemon peel oil its blends

S. No.	Properties	Diesel	B20 lemon peel oil
1	Specific gravity	0.8396	0.8437
2	Kinematic Viscosity	4.86	4.96
3	Calorific value	44000	43250
4	Flash point, ºC	51	55

Lemon peels are dried and grind oil with 6liter.

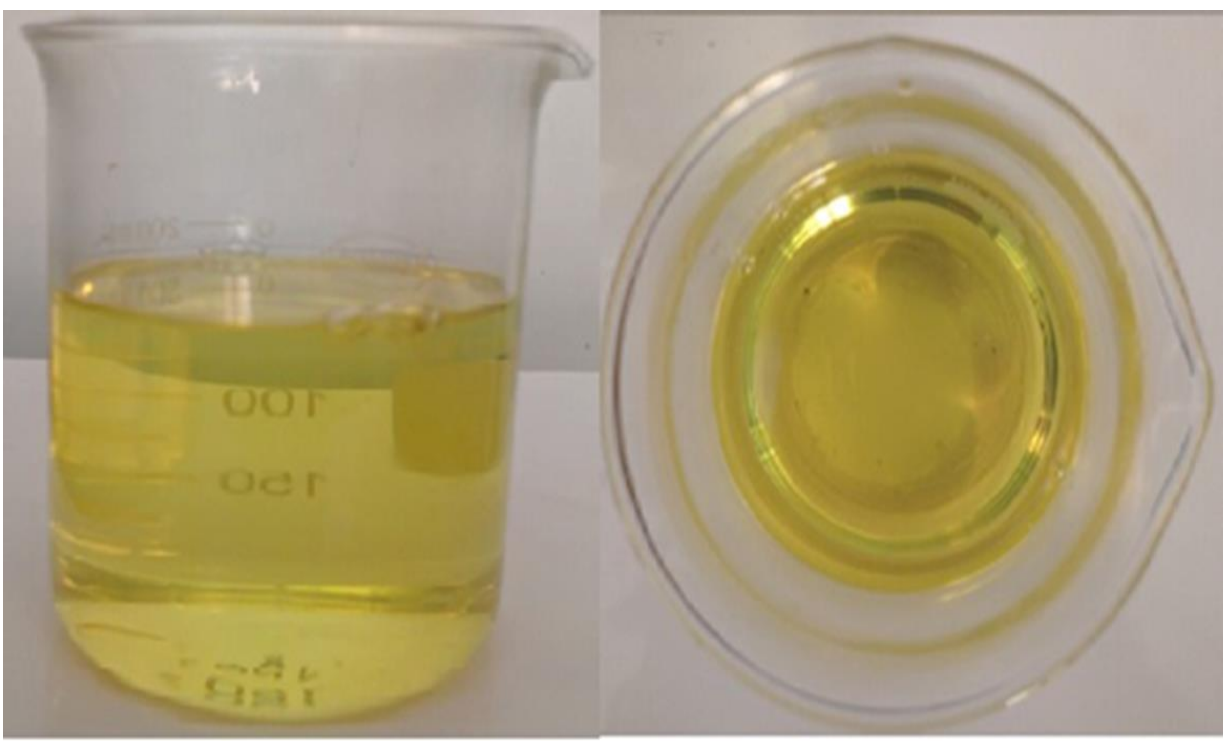
4.3.9 EXTRACTION OF LEMON PEEL OIL SAMPLES

4.3.10 BLENDING OIL SAMPLES

Lemon essential oil blend (40% LEO + 60%diesel)

Lemon essential oil blend (20% LEO + 80% diesel)

Lemon essential oil blend (30% LEO + 70% diesel)



5. READING ANDCALCULATON

FORMULAS

Maximum load:

$$W = BP \times 60 \times 1000 / 2\pi NRm$$

Where,

BP = Brake power
N = rated speed (1500 rpm)
R = Radius of dynamometer

Brake power:

$$BP = 2\pi N(W \times 9.81) / 60 \times 1000$$

Where,

T = Torque in Nm
N = Speed in rpm
W = Applied load

Friction power:

$$F.P = I.P - B.P$$

Specific fuel consumption:

$$SFC = TFC/BP$$

Indicated power:

$$IP = \frac{(IMEP) \times 10^5 \times LAN/2}{60 * 1000}$$

Where,

LAN = stroke length, Area of cylinder, speed
IMEP = indicated mean effective pressure

Total fuel consumption:

TFC = density of fuel / t

Where,

q = Volume of fuel consumed
t = Time taken for 10g fuel consumption

Brake thermal efficiency:

η Both = BP×100/TFC×CV

Where,

BP = Brake power
CV = Calorific value

Indicated thermal efficiency:

η th = IP×100/TFC×CV

where,

CV = Calorific value

Mechanical efficiency:

η mech = (BP / IP) *100

where,
BP = Brake power
IP = Indicated power

CALCULATION FOR LEMON PEEL OIL BIO-DESEL

Compression ratio = 19.5 Load = 9 kg

1. Brake power (BP) $= \dfrac{2\ \pi\ N\ (w \times 9.81)\ Rm}{60 \times 1000}$

$$= \frac{2\ \pi \times 1500 (9 \times 9.81)\ 185}{60 \times 1000}$$

$$= 2.56 KW$$

2. Indicated power (IP) $= \dfrac{(IMEP)\ 10^5\ LAN/2}{60000}$

$$= \frac{(5.66 \times 10^{5}) \times 110 \times 10^{-3} \times 6.01 \times 10^{-3} \times 1500}{60000 \times 2}$$

$$= 4.67\ KW$$

3.Total fuel consumption (TFC) $= \dfrac{q \times \text{Density of fuel}}{T}$

$$= \frac{10 \times (10^{-6}) \times 873}{36}$$

$$= 0.873\ Kg/hr$$

4.Specific fuel consumption (SFC) $= \dfrac{TFC}{BP}$

$$= \frac{0.873}{2.56}$$

$$= 0.34\ Kg/\ KW\ h$$

5. Mechanical efficiency (ηm) $= \frac{BP \times 100}{IP}$

$$= \frac{2.56 \times 100}{4.67}$$

$$= 54.8\ \%$$

6. Brake thermal efficiency (ηBT) $= \frac{BP \times 100}{TFC \times CV}$

$$= \frac{2.56 \times 100}{0.873 \times 11.41}$$

$$= 25.67\ \%$$

7. Indicated thermal efficiency(ηIT) $= \frac{IP \times 100}{TFC \times CV}$

$$= \frac{4.67 \times 100}{0.873 \times 11.41}$$

$$= 46.87\ \%$$

8. Volumetric efficiency (ηvol) = 163.2/2

$$=81.6\ \%$$

TABULATIONS

Load	Applied load	Time taken for 10cc of fuel consumption	RPM	BP	IP	TFC	SFC	η_{m}	η_{BT}	η_{IT}	η_{vol}
0	0	82.5	1500	0	0	0	0	0	0	0	0
25	4.5	45.38	1500	1.28	3.66	0.637	0.12	25.32	18.9	32.6	52
50	9	33.00	1500	2.96	4.67	0.873	0.34	54.8	25.6	46.87	81.6
75	13.5	26.20	1500	3.46	6.2	1.234	0.82	62.3	32.5	52.6	83.6
100	18	20.44	1500	5.29	7.35	1.832	1.23	69.24	37.67	61.3	88.5

6. PHOTOS AND CERTIFICATE

MSME - UAN - TN08E0020331 Phone : 9444765901, 9884468458

Sri Venkateswara Engineering Consultancy Services

(Engine Research Center)

Plot No.97, Lakshmi Flats, Sakthi Nagar, Vaiyavoor Road,
KANCHEEPURAM. PIN - 631 502.
E-mail : svecs1617@gmail.com

29th February 2020

CERTIFICATE

This is to certify that **D.GOKUL, C.RAMAKRISHNAN, N. RUTHRAPATHY**, U.G Students of Mechanical Department of **CARE GROUP OF INSTITUTIONS, TRICHY.** Has carried out experimental work at **Sri Venkateswara Engineering Consultancy Services, Kanchipuram- 631502.** The experiments were conducted on Kirloskar Single Cylinder Water Cooled Diesel Engine which is equipped With National Instruments Data Acquisition System, AVL Smoke meter 437C and AVL Digas 444N Analyzer and Eddy current Dynamometer. Using various bio diesel blend. The Performance, Combustion, and Emission characteristics were obtained for various loads for constant speed of 1500 rpm.

Research Coordinator

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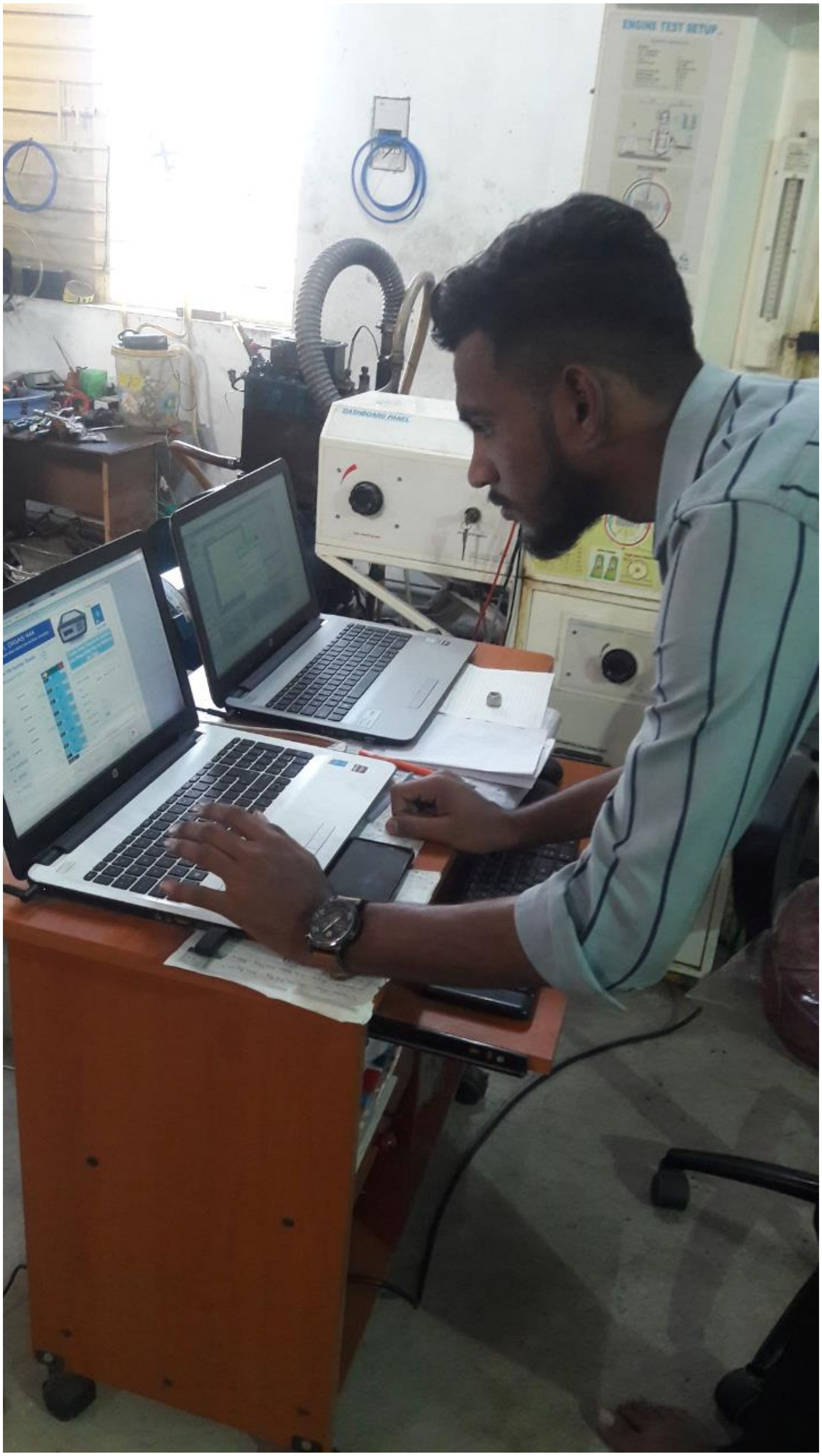
NGINE TEST SETUP


ENGINE TEST SETUP
DASHBOARD PANEL

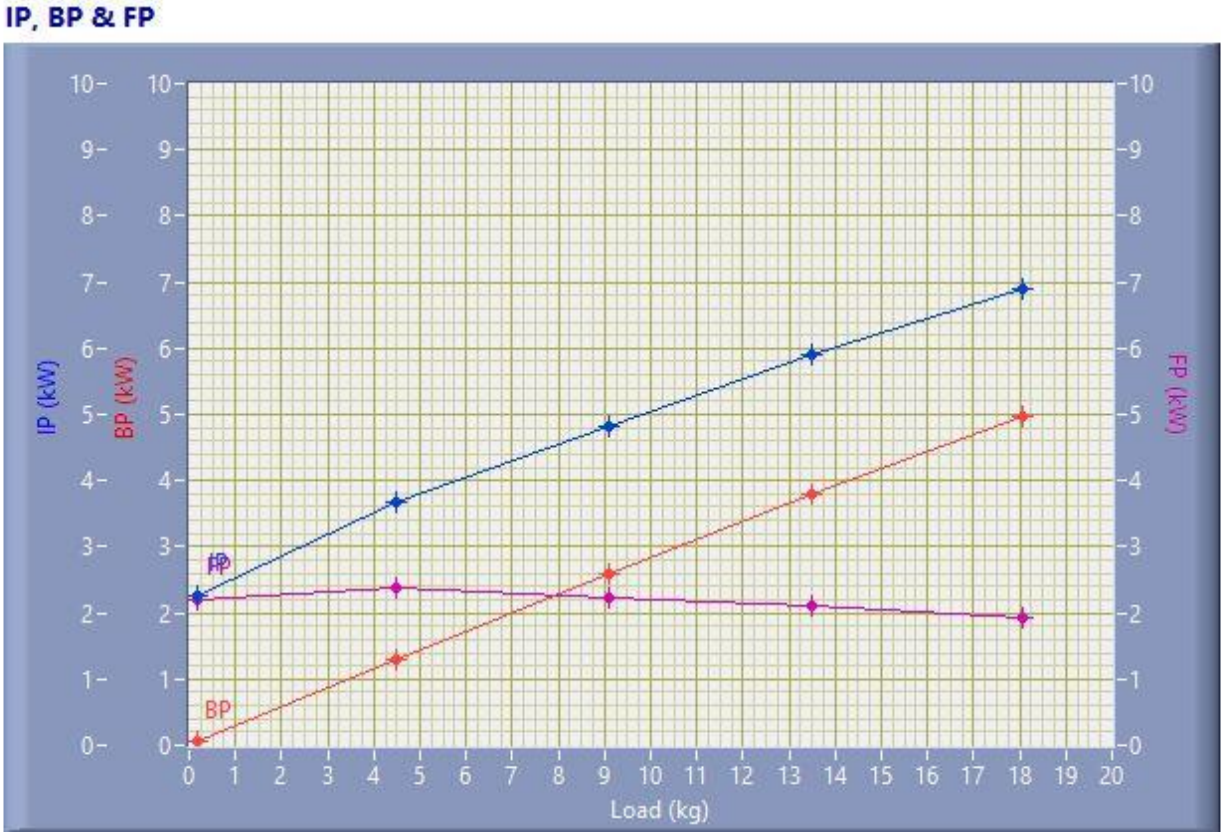
Company name: Venkateshwara industries' in Kanchipuram.

7. RESULTS AND DISCUSSIONS

7.1 PERFORMANCE

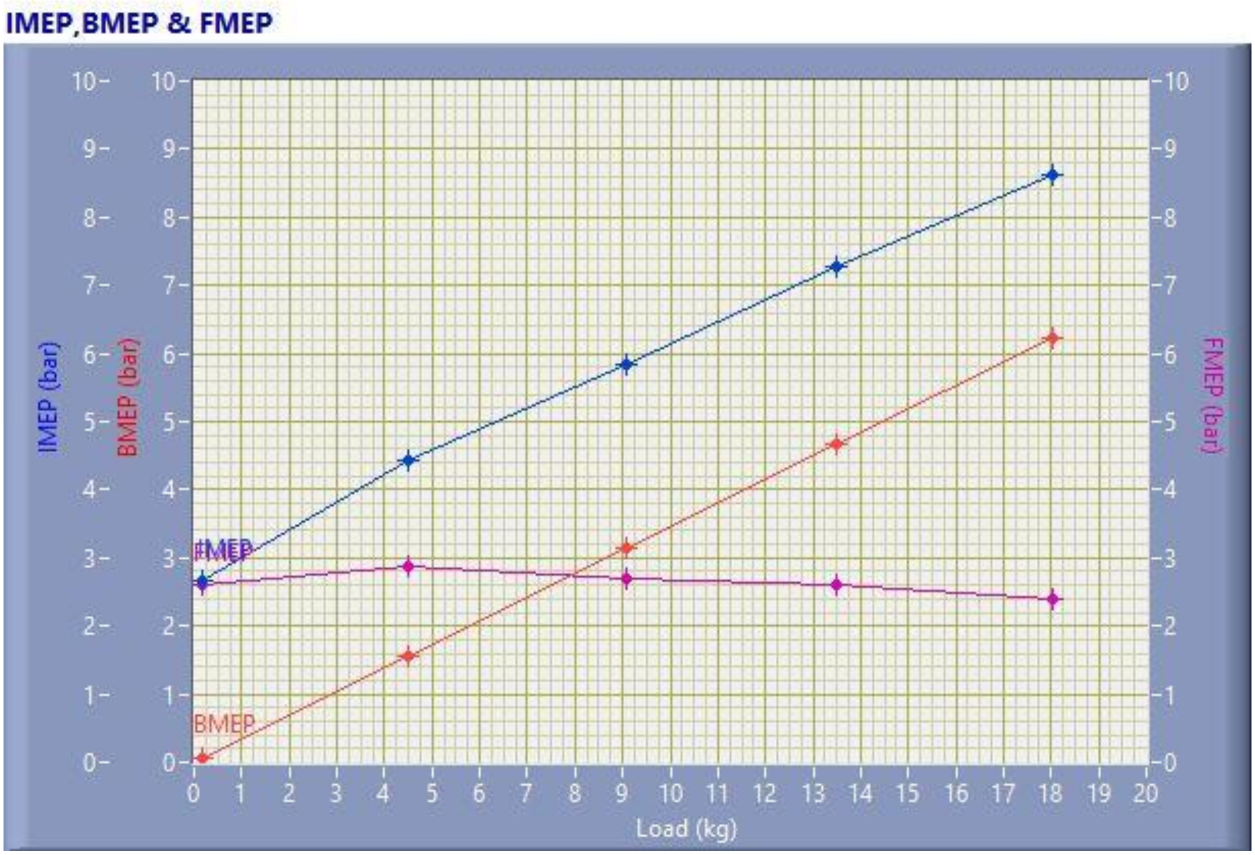
7.1.1 BRAKE POWER

The brake power values for B20 at different loads and at different compression ratio are shown. In general, the BP increases with increase in load. Demonstrates that both the fuel produced similar brake power. However, for higher compression ratio B20 produces more brake power especially at higher load. Due to shorter ignition delay the combustion starts earlier for biodiesel. This effect gets diminish with higher CR, as the temperature and pressure of the cylinder increases. Further, at higher load the inbuilt oxygen of biodiesel assists in complete combustion. It is also evident from the figure that the friction power of B20 is less than diesel. This factor also contributes in increasing BP for B20.



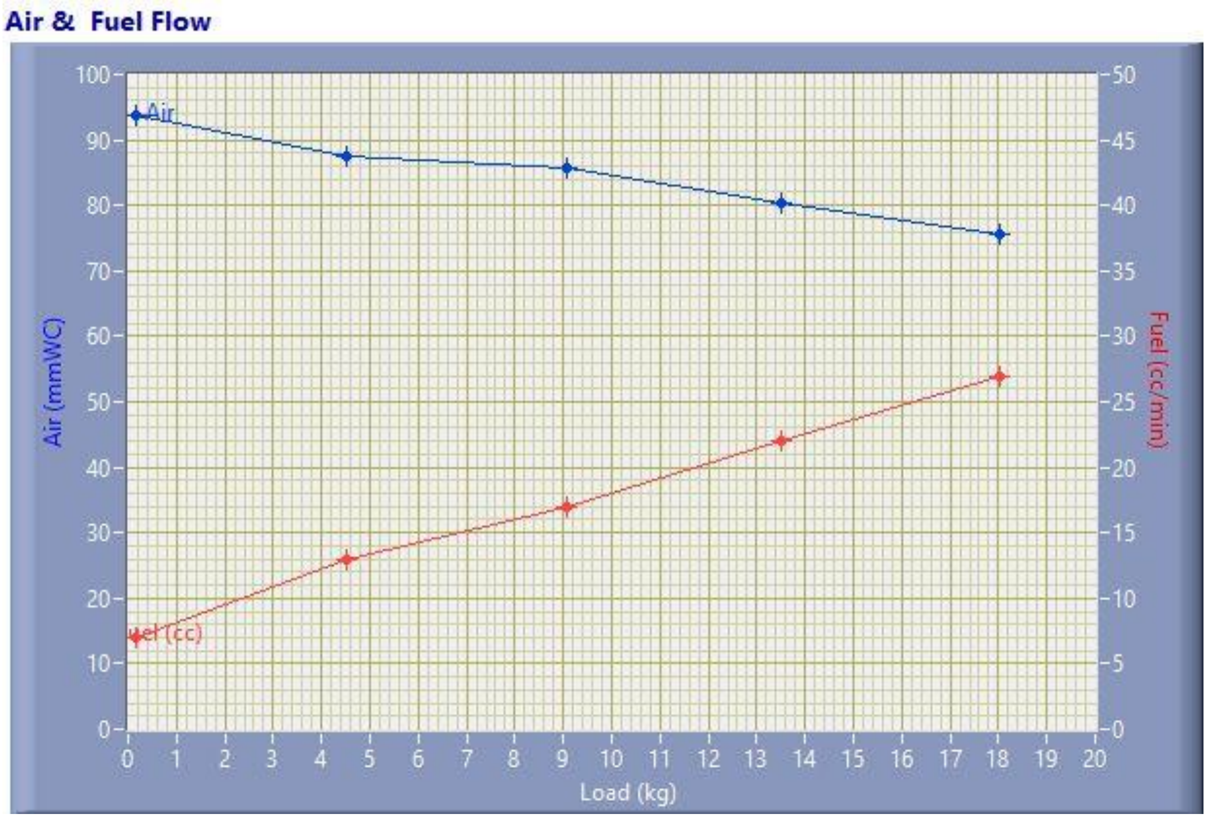
IP, BP & FP

Speed (rpm)	Load (kg)	IP (kW)	BP (kW)	FP (kW)
1545.00	0.17	2.26	0.05	2.21
1512.00	4.50	3.68	1.29	2.39
1502.00	9.08	4.83	2.59	2.24
1476.00	13.50	5.91	3.79	2.12
1452.00	18.04	6.90	4.98	1.92



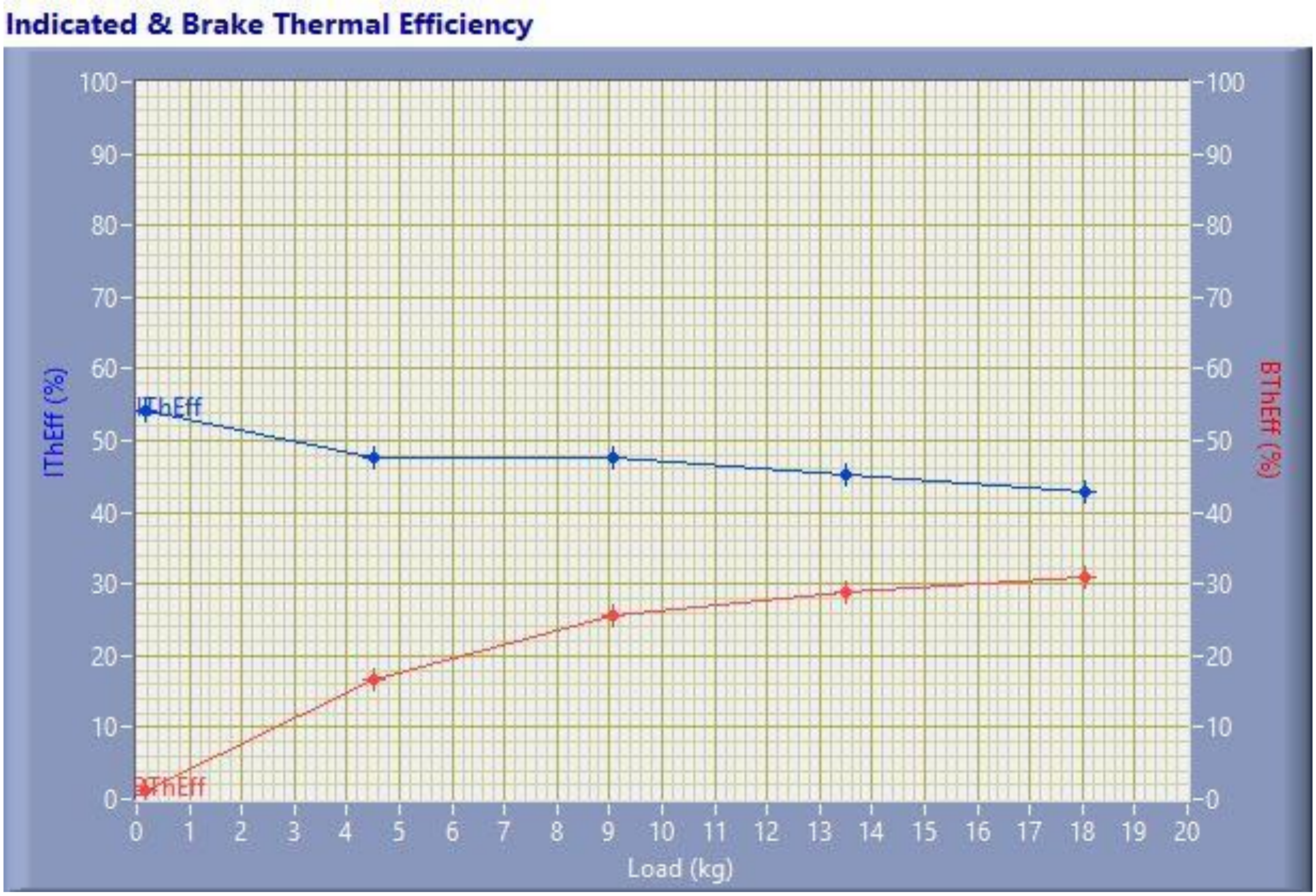
IMEP, BMEP & FMEP

Speed (rpm)	Load (kg)	IMEP (bar)	BMEP (bar)	FMEP (bar)
1545.00	0.17	2.66	0.06	2.60
1512.00	4.50	4.42	1.55	2.87
1502.00	9.08	5.83	3.13	2.70
1476.00	13.50	7.26	4.66	2.61
1452.00	18.04	8.62	6.22	2.40



Air & Fuel Flow

Speed (rpm)	Load (kg)	Air (mmWC)	Fuel (cc/min)
1545.00	0.17	93.85	7.00
1512.00	4.50	87.38	13.00
1502.00	9.08	85.80	17.00
1476.00	13.50	80.44	22.00
1452.00	18.04	75.65	27.00



Indicated & Brake Thermal Efficiency

Speed (rpm)	Load (kg)	IThEff (%)	BThEff (%)
1545.00	0.17	54.31	1.19
1512.00	4.50	47.63	16.73
1502.00	9.08	47.77	25.63
1476.00	13.50	45.15	28.94
1452.00	18.04	42.98	31.00

7.1.2 BRAKE THERMAL EFFICIENCY (BTE)

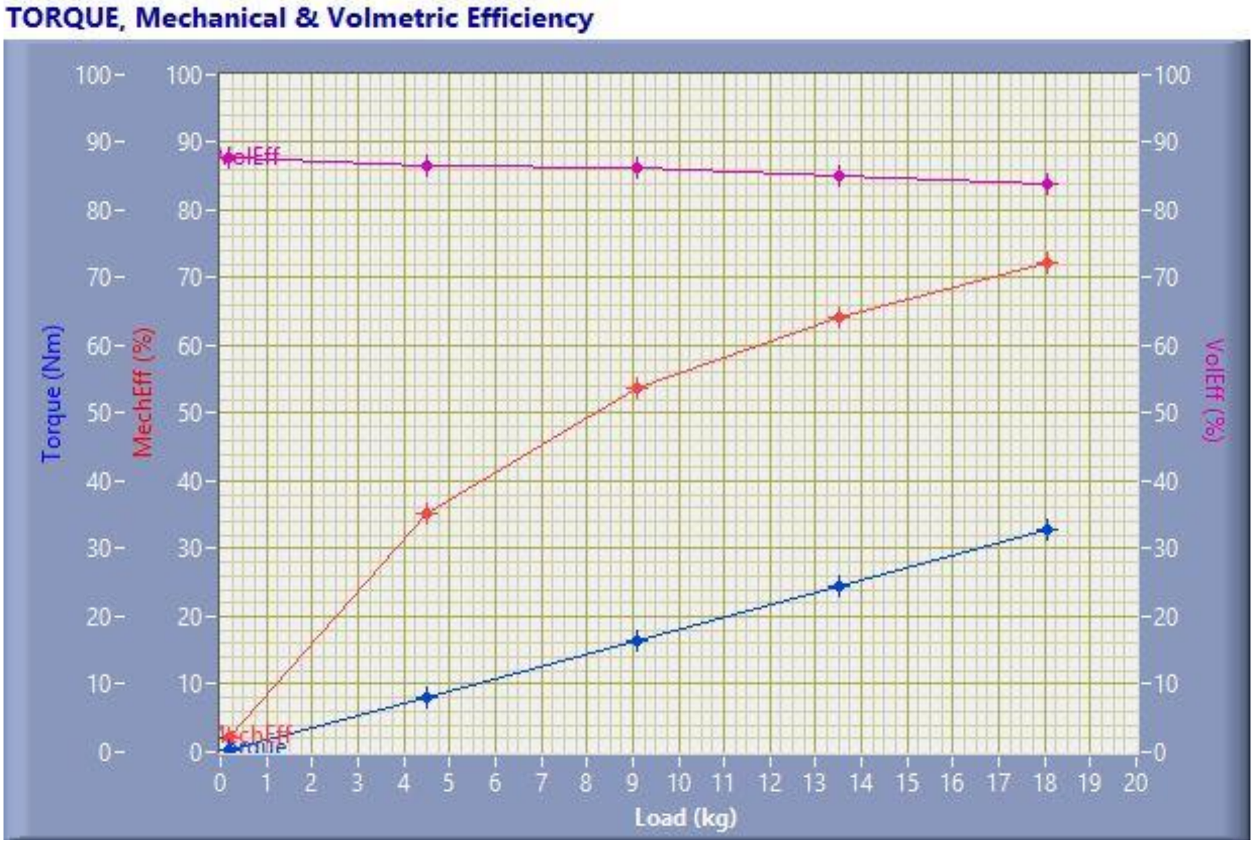
Brake thermal efficiency (BTE) is the ability of the combustion system to accept the experimental fuel, and it provides the comparable means of assessing how efficient the energy in the fuel was converted into mechanical output. The variation of brake thermal efficiency with respect to load for B20. Depicts that the thermal efficiency increases with increase in load also it can be observed from that Brake thermal efficiency improves at higher compression ratios. The reasons for this improvement of Brake thermal efficiency is better combustion and better lubricity of biodiesel. The maximum brake thermal efficiency is obtained at a compression ratio of 19, due to the superior combustion and better intermixing of the fuel.

7.1.3 BRAKE SPECIFIC FUEL CONSUMPTION (BSFC)

BSFC is an important parameter that reflects how good the engine performance is. The variation of BSFC with load at different compression ratio. Generally, the BSFC decreases with increase in load due to fact that the ratio of increase in brake power is more as compared to increase in fuel in fuel consumption. It is found the BSFC of B20 more as compared to diesel when experimented at different compression ratios. The reason for this increase in BSFC is low heat value of esters of vegetable oils compared to diesel so more BP is needed to maintain the power output. These findings were also reported by others researchers.

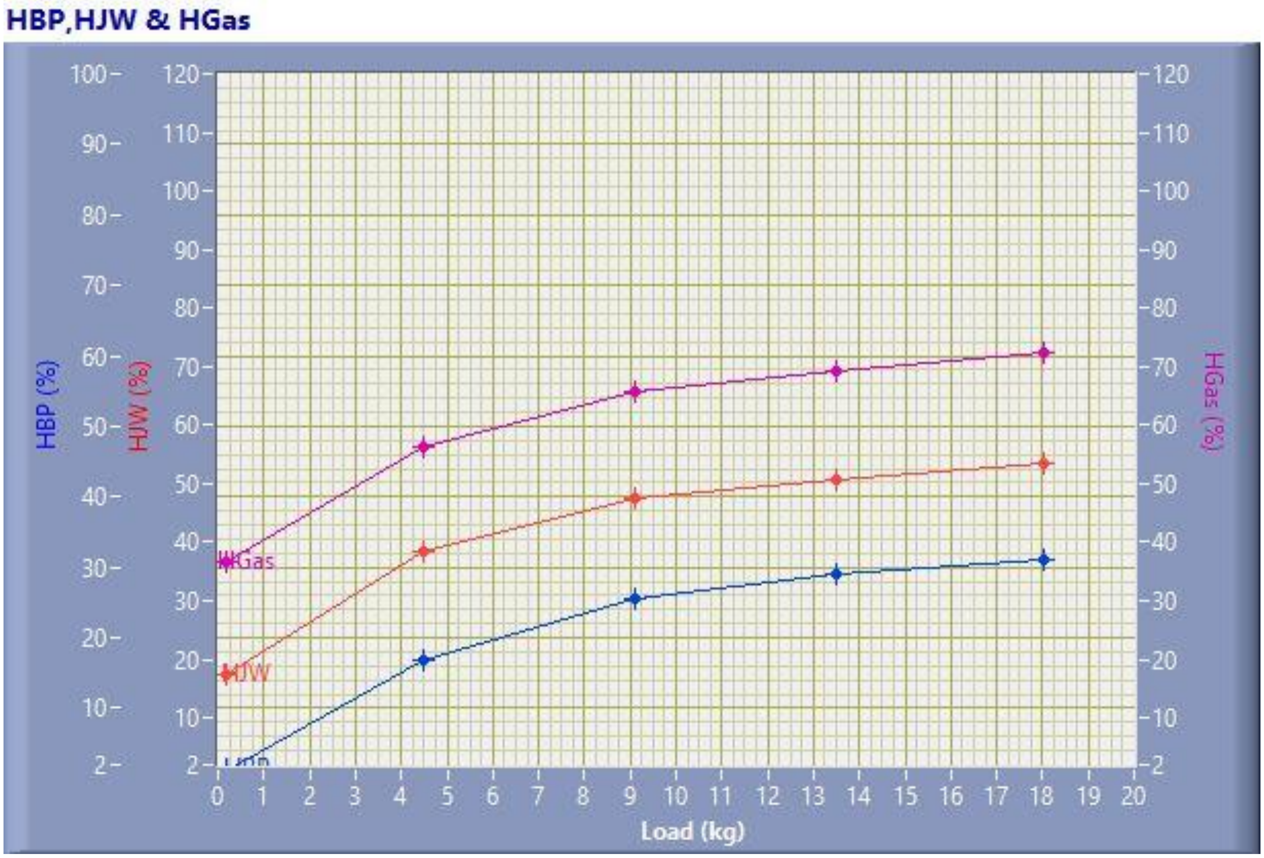
SFC & Fuel Consumption

Speed (rpm)	Load (kg)	SFC (kg/kWh)	Fuel (kg/h)
1545.00	0.17	7.21	0.36
1512.00	4.50	0.51	0.66
1502.00	9.08	0.34	0.87
1476.00	13.50	0.30	1.12
1452.00	18.04	0.28	1.38



TORQUE, Mechanical & Volumetric Efficiency

Speed (rpm)	Load (Kg)	Torque (Nm)	Mech Eff. (%)	Vol Eff. (%)
1545.00	0.17	0.31	2.19	87.66
1512.00	4.50	8.17	35.12	86.43
1502.00	9.08	16.48	53.67	86.22
1476.00	13.50	24.51	64.11	84.95
1452.00	18.04	32.75	72.13	83.74



HBP, HJW & HGas

Speed (rpm)	Load (kg)	HBP (%)	HJW (%)	HGas (%)	HRad (%)
1545.00	0.17	1.19	16.04	19.42	63.35
1512.00	4.50	16.73	21.69	17.98	43.59
1502.00	9.08	25.63	21.89	18.31	34.16
1476.00	13.50	28.94	21.82	18.46	30.78
1452.00	18.04	31.00	22.43	19.04	27.52

Observation Data

Speed (rpm)	Load (kg)	Comp Ratio	T1 (deg C)	T2 (deg C)	T3 (deg C)	T4 (deg C)	T5 (deg C)	T6 (deg C)
1545	0.17	17.50	41.38	45.20	41.38	39.59	109.96	89.68
1512	4.50	17.50	41.58	51.17	41.58	41.97	173.33	133.89
1502	9.08	17.50	41.61	54.26	41.60	43.95	222.31	169.80
1476	13.50	17.50	41.59	57.91	41.60	46.76	287.68	217.62
1452	18.04	17.50	41.58	62.17	41.57	49.86	363.99	270.19

Observation Data

Air (mmWC)	Fuel (cc/min)	Water Flow Engine (lph)	Water Flow Cal (lph)
93.85	7.00	150	75
87.38	13.00	150	75
85.80	17.00	150	75
80.44	22.00	150	75
75.65	27.00	150	75

DATA RESULTS

Result Data

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.31	0.05	2.21	2.26	0.06	2.66	1.19	54.31	2.19
8.17	1.29	2.39	3.68	1.55	4.42	16.73	47.63	35.12
16.48	2.59	2.24	4.83	3.13	5.83	25.63	47.77	53.67
24.51	3.79	2.12	5.91	4.66	7.26	28.94	45.15	64.11
32.75	4.98	1.92	6.90	6.22	8.62	31.00	42.98	72.13

Result Data

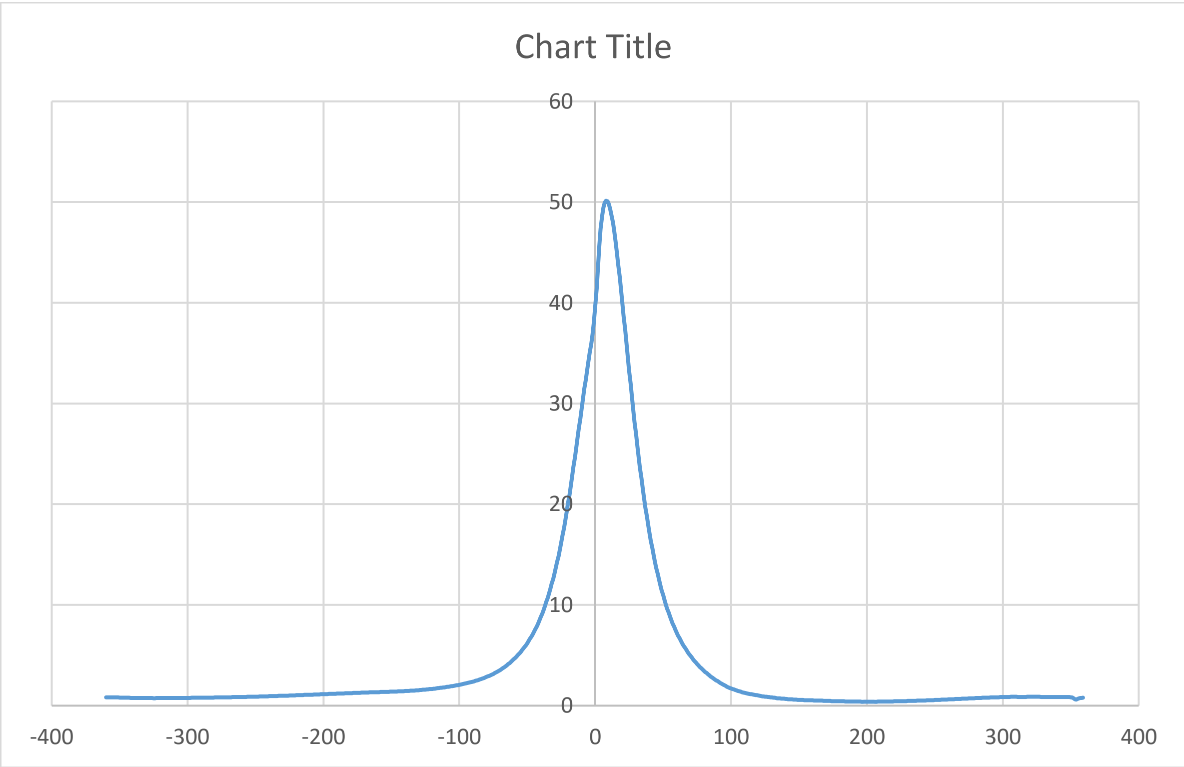
Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
31.55	0.36	7.21	87.66	88.16	1.19	16.04	19.42	63.35
30.44	0.66	0.51	86.43	45.81	16.73	21.69	17.98	43.59
30.17	0.87	0.34	86.22	34.71	25.63	21.89	18.31	34.16
29.21	1.12	0.30	84.95	25.97	28.94	21.82	18.46	30.78
28.33	1.38	0.28	83.74	20.52	31.00	22.43	19.04	27.52

7.2 EMISSIONS

7.2.1 HC EMISSION

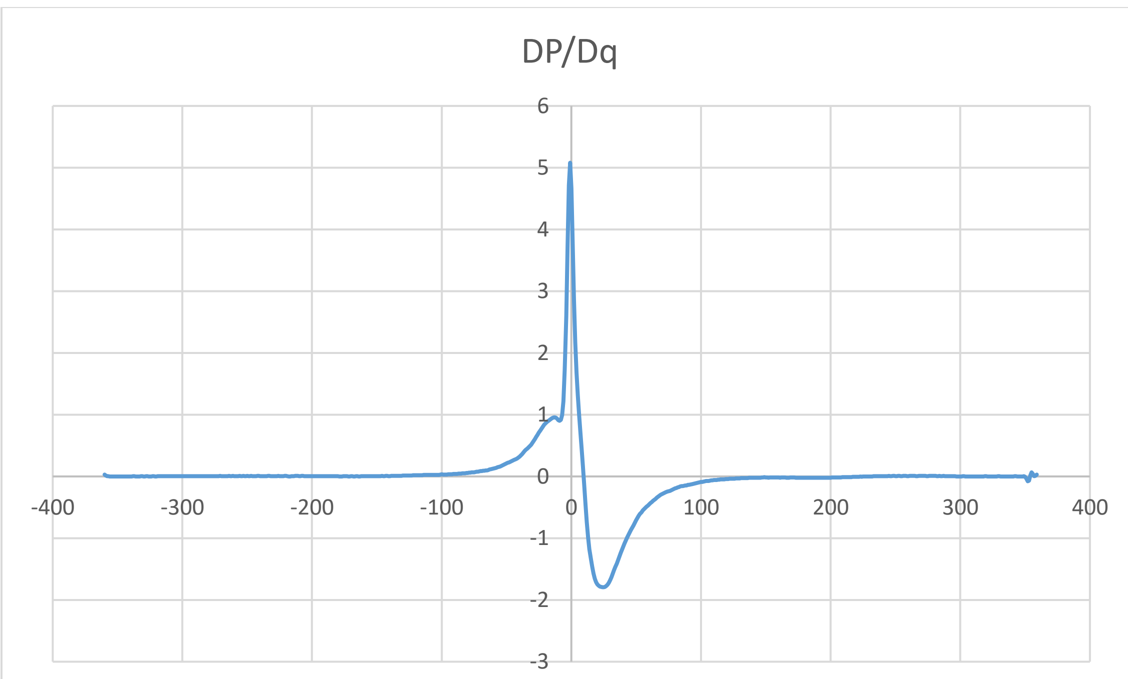
The unburned fuel component present in exhaust of an engine consists hydrocarbon component is termed as HC emission. These hydrocarbons consist of small non-equilibrium molecules, which are formed when large fuel molecules break up by thermal cracking during combustion reactions. The major cause of HC emission is non-homogeneity of fuel- air mixture. Due to this non-homogeneity some local zones in combustion chamber will be too lean to combust properly and other zones may be too rich with not enough oxygen to burn all the fuel. The HC emission of CI engine with load. It can be observed that HC emission decreases as the load increases. Generally, HC emission from exhaust is measure of unburnt fuel in the exhaust of an engine. HC emission using biodiesel is lower than diesel. This is due to the fact that the cetane number of ester based fuel is higher than diesel and so results in better combustion leading to lower emission.

EMISSIONS CHARTS

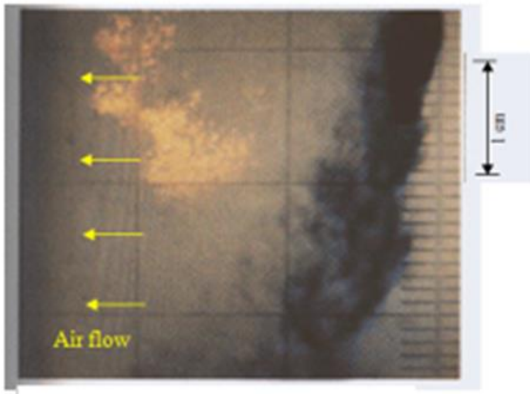


7.2.2 CO EMISSION

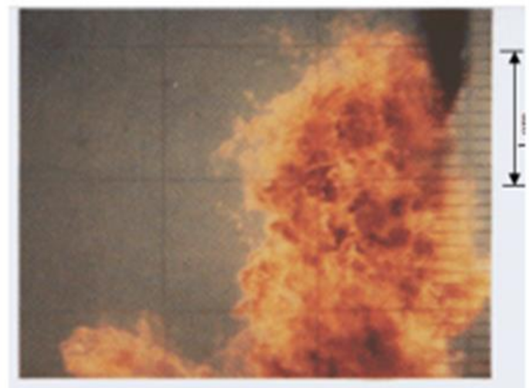
The presence of CO in the exhaust of an engine is a representation of the chemical energy of the fuel that is not fully utilized. Carbon monoxide is a colorless and odorless but a poisonous gas. Generally, the CO emission is affected by the equivalence ratio, fuel type, combustion chamber design, and atomization rate, start of injection timing, engine load, and speed. The most important among these parameters is the equivalence ratio. The CO emission decreases as the load on an engine increase. This is a typical result for internal combustion engines because the combustion temperature increases with the engine load and CO emission reduces. The CO emission variation with load. Depicts that CO emission decreases as load increases and it has been observed that CO emission decreases as the compression ratio increases. Higher the HC emission, lower the CO emission.



Post Ignition Process in CI Engines



0.4 ms after ignition



3.2 ms after ignition

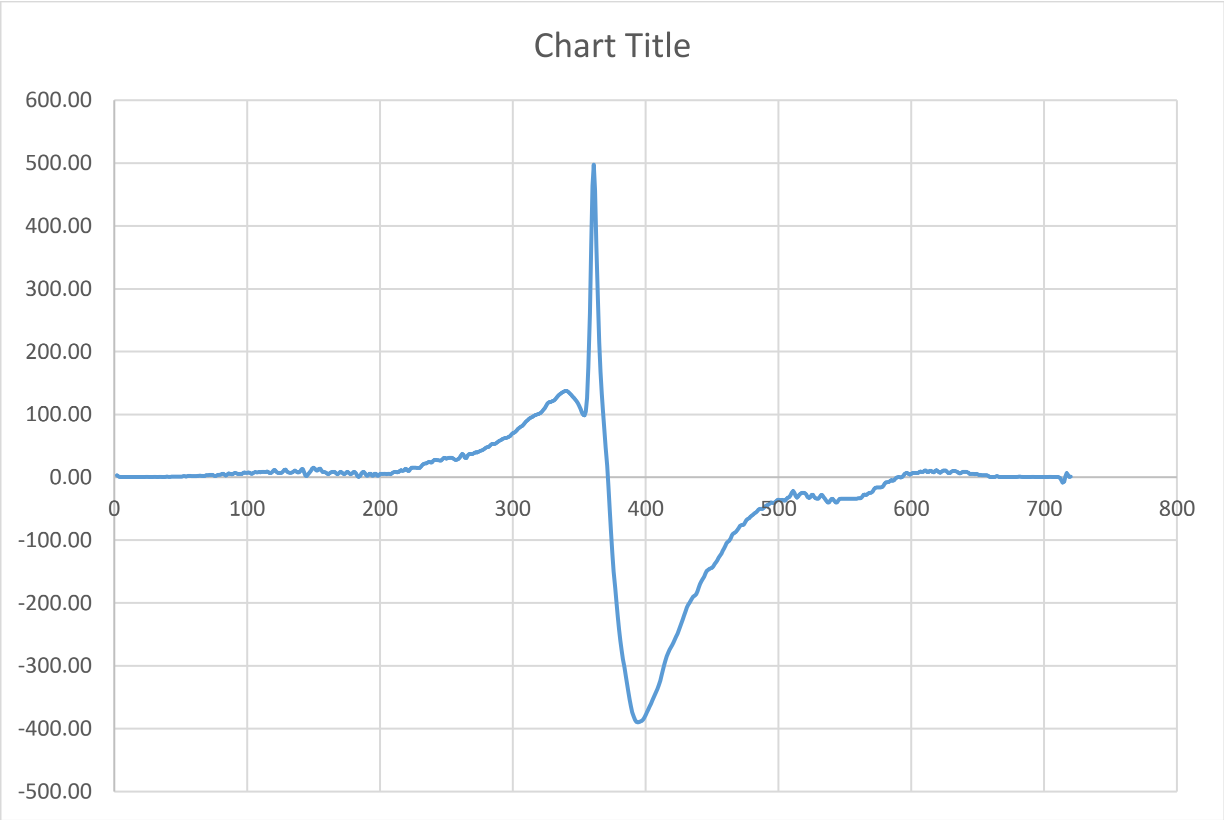
5.0 ms after ignition

Late in combustion process

Source: http://www.sciencedirect.com/science/article/pii/S00

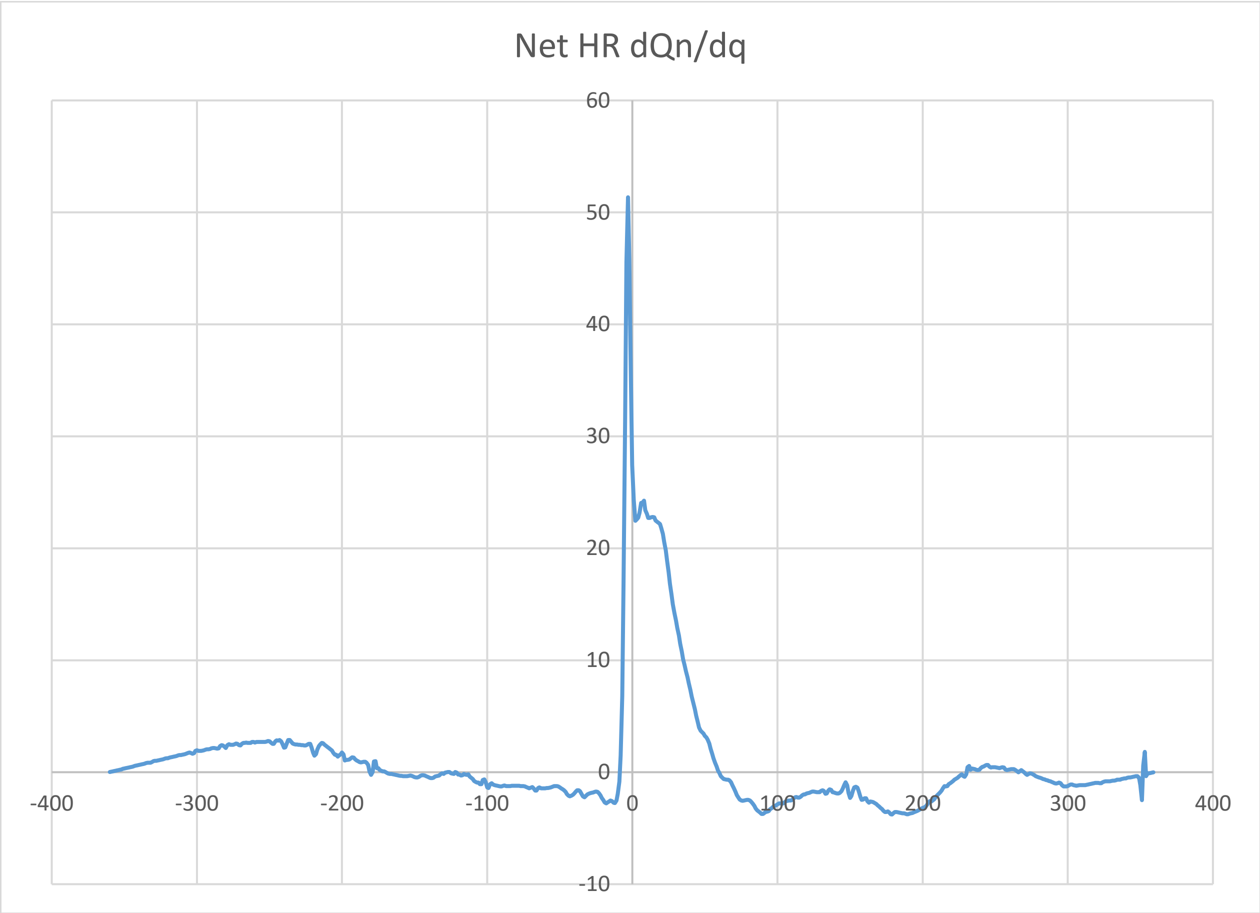
7.2.3 CO2 EMISSION

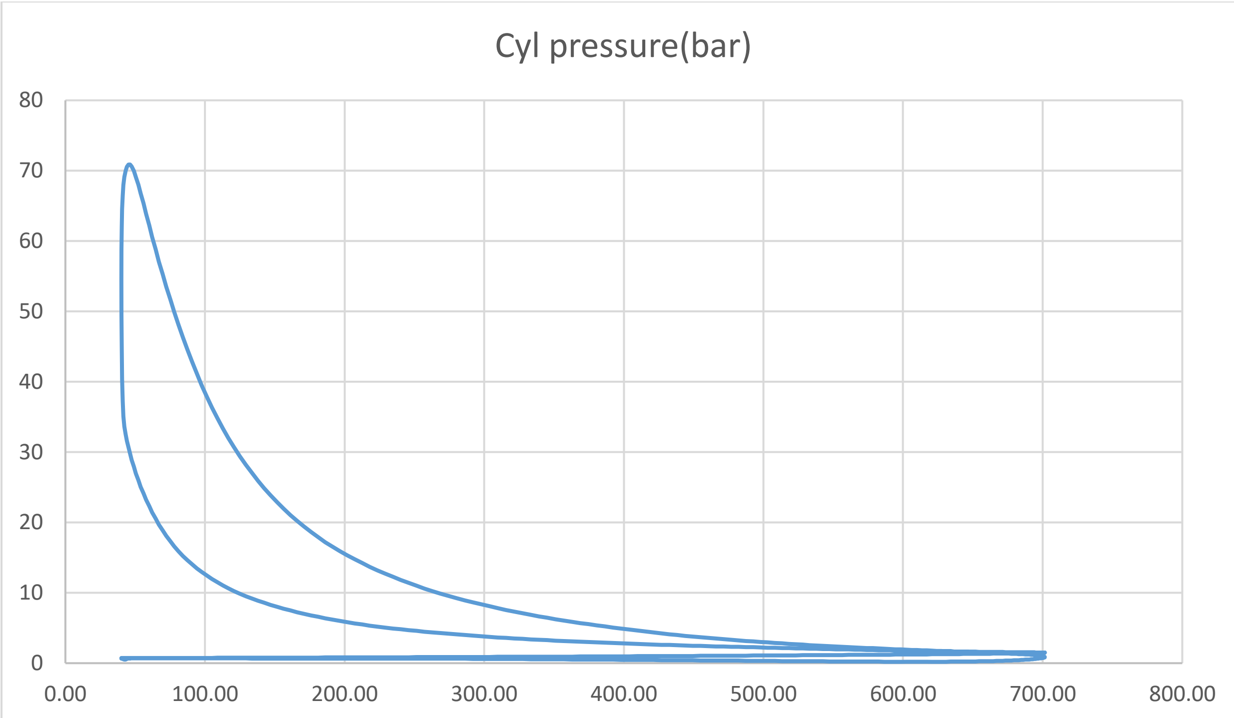
The higher CO2 emission in the exhaust of internal combustion engine is indication of better combustion of fuel. The CO2 emission increases as the load on an engine increase. This is due to the fact that at higher loads the combustion temperature increases which helps in complete combustion of the fuel. The CO2 emission versus load graph. The graph showed that CO2 emission increases as the load increases. Amount of CO2 in the exhaust is an indication of the combustion of the fuel inside the cylinder. More amount of CO2 in exhaust means better combustion.



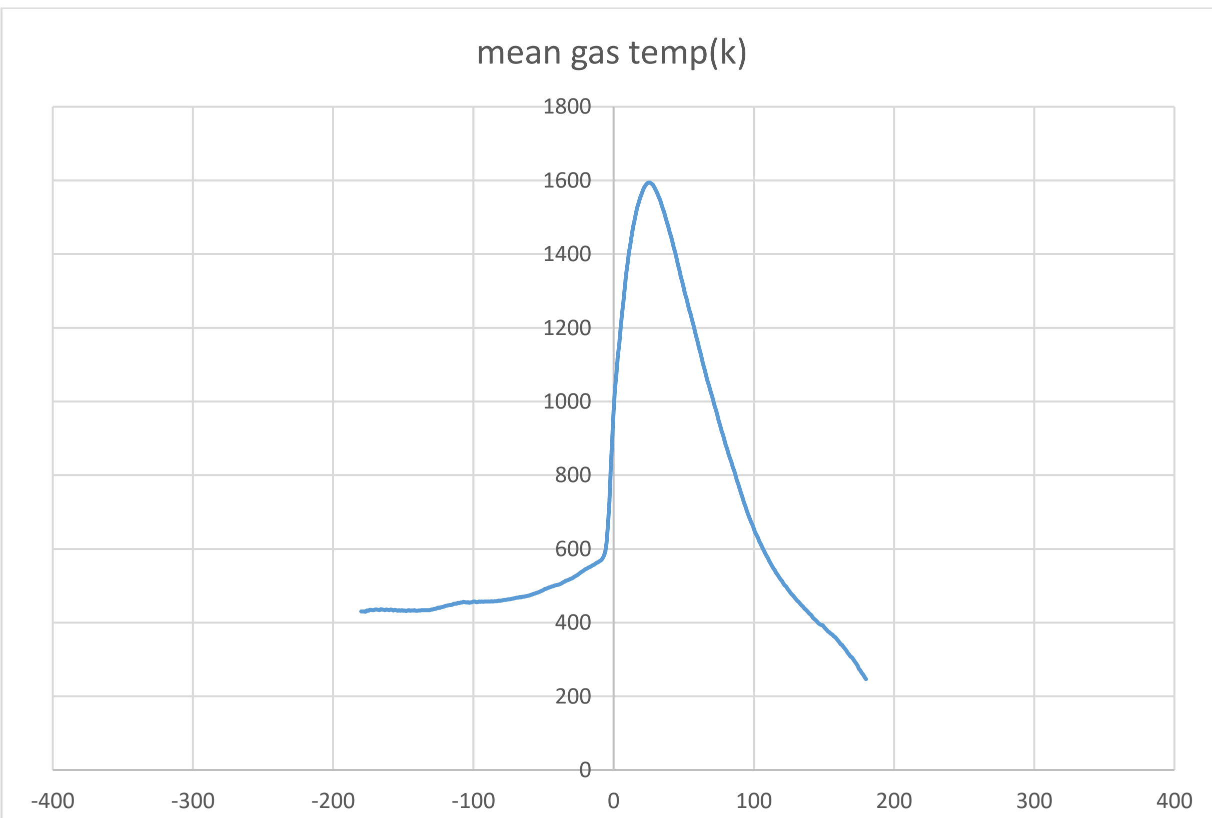
7.2.4 O2 EMISSION

The variation of oxygen emission in the exhaust is shown. The figure shows that the oxygen emission decreases with increase in load. This is due to better combustion at higher loads. Further it is observed that oxygen emission of biodiesel (B20) is more than diesel this is due to the fact that the biodiesel contains nearly 10% inbuilt oxygen. Similar trend is obtained on increasing the compression ratio this is again due to nearly complete combustion of fuel.





Cyl pressure(bar)
80
70
60
50
40
30
20
10
0
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00



mean gas temp(k)
1800
1600
1400
1200
1000
800
600
400
200
0
-400
-300
-200
-100
0
100
200
300
400

7.2.5 SMOKE OPACITY

Formation of smoke is basically a process of conversion of molecules of hydrocarbon fuels into particle of soot. The soot is an agglomeration of very large polybenzenoid free radicals. The soot formation takes place during early part of actual combustion but it is consumed during later part of combustion. Pyrolysis of fuel molecules themselves thought to be responsible for soot formation. The air or oxygen deficiency is locally present inside diesel engines. The variation of smoke emission at different loads for different fuels is shown. The significant reduction in smoke emission for the biodiesel (B20) may be due to the oxygenated blends. As discuss earlier the 10% inbuilt oxygen provides better and nearly complete combustion.

7.3 Gas Emission Report

Equipment: AVL Digas 444 N Gas Analyzer

AVL Smoke meter 437 C

S.NO	Veh.ID No.	CO	HC	CO2	O2	NOX	LAMBDA	Opacity
		%	PPM	%	%	PPM		%
1.	29-02 LP B20 00	0.015	5	1.79	18.6	89	8.054	8.6
2.	29-02 LP B20 25	0.009	9	3.87	15.23	462	3.747	27.3
3.	29-02 LP B20 50	0.015	12	5.36	13.45	982	2.724	36.2
4.	29-02 LP B20 75	0.016	21	7.23	10.86	1352	2.045	51.2
5.	29-02 LP B20 100	0.119	48	10	7.08	1573	1.479	70.3

7.4 COST ESTIMATION'S

S.NO	DESCRIPTION	QUANTITY / NO OF READINGS	AMOUNT IN RS
1.	PEEL OIL	1 Liters	2000
2.	DIESEL CHARGES FOR FCR ENGINE	5 Liters	350
3.	READING CHARGES IN CRDI ENGINE	3 Reading	6,000
	TOTAL		RS. 8,350

SUMMARY AND CONCLUSION

8. SUMMARY AND CONCLUSION

The current study aimed at finding the effects of variations in engine operating parameters on the emissions of NOx while operating with pure biodiesel. At standard operating parameters, the emissions of NOx are found to be lesser with JME as compared to diesel as fuel. It is observed that increase in compression ratio tends to raise the emission level of NOx whereas increase in injection pressure leads to reduction in NOx emissions. While using pure JME as fuel, high compression ratio associated with high injection pressure, results in lower NOx emissions as compared to diesel emissions. At lower speeds of engine, the emissions increase peaking at 1500 rpm. The effect of retarding the injection timing is positive as emission of NOx tends to decrease with retardation. Thus, NOx emissions can be minimized by increasing compression ratio, increasing injection pressure, maintaining engine speed and retarding injection timing from standard values of these parameters.

The Break thermal efficiency, Mechanical efficiency and efficiency ratios are higher for lemon oil diesel Break Specific fuel consumption is lower and Break Power is almost similar with minor variations for the lemon oil diesel due to enhanced combustion. Indicated mean effective pressure is higher for the neem bio diesel due to efficient combustion. The various emissions namely CO, CO2, HC, SOx and O2 decreasing for the both diesels. The NOx emission increasing for all the bio diesel due to increase of cylinder temperature. The Smoke emission is also lower for both diesel at higher loads due to enhanced combustion.

Based on the performance and emissions of fuel, it is concluded that the lemon peel oils fuel oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the analysis the bio fuel shows better performance compared to the Diesel in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption, Mechanical efficiency, A/F ratio. Hence the bio fuel can be used as a substitute for diesel.

The main objective of the present investigation was to evaluate the suitable lemon peel oil-diesel blend in terms of engine performance and emissions. The performance and emissions tests were conducted with diesel, and blends of lemon peel oil at different loads and at constant speed (1500 rpm). From the experimental results obtained, lemon peel oil blends are found to be a promising alternative fuel for compression ignition engines. The performance parameters such as brake thermal efficiency, brake power, brake mean effective pressure for all lemon peel blends was found to be higher as compared to diesel.

9. NOMENCLATURE

1. ASTM – American Society for Testing and Materials.
2. LEO – Lemon Essential oil.
3. BTDC – Before top dead centre BTE.
4. CL – Citrus lemon.
5. CI – Compression engine.
6. NOX – Oxides' of nitrogen.
7. BSFC – Break specific energy consumption.
8. CRDI – Common rail direct injection.

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