

**ENGINE PERFORMANCE EMISSION AND COMBUSTION
CHARACTERISTICS OF DI ENGINE FUELLED WITH CUSTARD
APPLE WITH TiO₂ AS A NANO ADDITIVE**

Submitted in partial fulfilment of the requirements for the award of Bachelor of
Engineering in Mechanical Engineering.

By

YOGAPRAVEEN. S - 38150128



**DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL OF
MECHANICAL ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MAY – 2022



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC - 12B Status by UGC – Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the genuine work of **YOGAPRAVEEN S** (Reg. No. **38150128**) who worked on the project entitled **ENGINE PERFORMANCE EMISSION AND COMBUSTION CHARACTERISTICS OF DI ENGINE FUELLED WITH CUSTARD APPLE WITH TiO₂ AS A NANO ADDITIVE** under my supervision from September 2021 to April.

Internal Guide


Mr. S. LAKSHMI SANKAR, M.E, Ph.D.,


Head of the Department

Dr. G. ARUNKUMAR, M.E, Ph.D.,

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I , **YOGAPRAVEEN S (38150128)** hereby declare that the Project Report entitled **Engine performance emission and combustion characteristics of di engine fuelled with custard apple with TiO₂ as a Nano additive.** done by me under the guidance of **Mr. S. LAKSHMI SANKAR M.E., (Ph.D.,)** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering

DATE:

PLACE: CHENNAI



SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

This initiative was made possible by the wonderful support of the SATHYABAMA Board of Management, and I would like to express my gratitude to them. For that, I am very thankful.

During the review process, I would like to express my gratitude to the Dean of the School of Mechanical Engineering and the department's head for giving me with the information and assistance I needed at the correct moment. I am grateful for their help and support.

Please accept my heartfelt thanks to Mr. S. LAKSHMI SANKAR, M. E., (Ph.D.,) for his invaluable advice, recommendations, and persistent support that helped me complete my project work to the best of my abilities.

Throughout the project, I would want to convey my gratitude to all members of the Mechanical Engineering Department's teaching and non-teaching personnel.

ABSTRACT

There is an increasing need for biodiesel as a transportation fuel. Custard apple oil has been employed in a diesel engine in this study. B5, B10, B15, and B20 were the biodiesel blends that were offered. B20 fuels outperformed other blends in terms of performance and exhaust emissions, such as smoke, carbon monoxide, and unburned hydrocarbons, which were all decreased. In comparison to other gasoline mixes, B20 has greater NO_x emissions. This article compares the quality of biodiesel fuel, engine performance, and emission characteristics. Biodiesel is a renewable, low-carbon fuel that may be utilised to minimise global carbon emissions. As a by-product of bio-mass production, biodiesel is an excellent alternative to conventional fossil fuels for fulfilling the rising need for transportation fuels that comes along with strong economic growth, as well as the high energy demands of India's enormous rural population.

In addition to lowering our dependency on crude oil, biofuels also assist to create a cleaner and more sustainable environment. On top of all of that, it provides rural communities with more revenue and job opportunities. Both rural India's energy requirements and the country's growing transportation needs will be met as a result of this. For the 21st century, the use of carbon fuels will cut carbon emissions and fulfil the energy needs of the century.

TABLE OF CONTENT

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	v
	LIST OF FIGURES	vi
	LIST OF TABLES	ix
	LIST OF ABBREVIATIONS	x
1.	CHAPTER1 -1	
	1.1 INTRODUCTION	1
	1.2 BIOFEUL	2
	1.3 CUSTARD APPLE OIL	4
	1.4 PROPERTIES OF CUSTARD APPLE OIL	5
2	CHAPTER- 2	
	2.1 LITERATURE SURVEY	6
3.	CHAPTER- 3	
	3. 1 AIM OF THE PROJECT	9
	3. 2 SCOPE OF THE PROJECT	9
4	CHAPTER- 4	
	4. 1 METHODOLOGY	11

4. 2 EXPERIMENTAL SETUP	12
4.3 VCR ENGINE TEST SETUP-	13
PERMORMANCE TEST RIG	
4.4 FEATURES	13
4.5 RANGE OF EXPEIMENTS	14
4.6 UTILITIES	14
4.7 SPECIFICATION OF ENGINE	16
4.8 GAS ANALYZER	18
4.9 SAMPLE PREPARATION	21
4.9.1 SAMPLE OF CUSTARD APPLE OIL	21
4.10 EXPERIMENTAL WORK	22
4.11 EMISSION OF CO GAS	22
4.12 EMISSION OF HC GAS	23
4.13 EMISSION OF NO _x GAS	24
4.14 EMISSION OF CO ₂ GAS	25
4.15 EMISSION OF O ₂ GAS	25

5

CHAPTER- 5

5.1 SAMPLE-1(S1) RESULTS	27
5.2 SAMPLE-2(S2) RESULTS	29

5.3 SAMPLE-3(S3) RESULTS	31
5.4 SAMPLE-4(S4) RESULTS	33
5.5 HC EMISSION VS BP	36
5.6 CO ₂ EMISSION VS BP	37
5.7 NO _x EMISSION VS BP	38
5.8 CO EMISSION VS BP	39
5.9 O ₂ EMISSION VS BP	40
5.10 BTHE VS BP	41
5.11 SFC VS BP	42
5.12 RESULTS	43
5.13 RESULT DATA PURE DIESEL	43
5.14 RESULT DATA PURE DIESEL	44
5.15 EMISSION DETAILS FOR 3.5 KW	44

DIESEL ENGINE

6

CHAPTER- 6

6.1 CONCLUSION	48
6.2 REFERENCES	49

LIST OF FIGURES

TABLE NO	TITLE	PAGE NO
4.1	Schematic diagram of the engine	12
4.2	Gas analyzer	14
4.3	Smoke meter	18
4.4	Smoke meter	20
4.5	Smoke meter	20
4.6	Sample	21
5.1	HC EMISSION VS LOAD GRAPH	36
5.2	CO EMISSION VS LOAD GRAPH	37
5.3	CO ₂ EMISSION VS LOAD GRAPH	38
5.4	O ₂ EMISSION VS LOAD GRAPH	39
5.5	NO _x EMISSION VS LOAD GRAPH	40
5.6	BTHE VS LOAD GRAPH	41
5.7	SFC VS LOAD GRAPH	42
6.1	COMBINED RESULTS OF 4SAMPLES & BTHE , SFC	

LIST OF TABLES

TABLE NO	TITLE	PAGE NO
4.1	SPECIFICATION OF ENGINE	16
4.2	SMOKE METER	19
4.3	SAMPLE OF CUSTARD APPLE OIL	21
5.1	SAMPLE-1(S ₁) TABLE	28
5.2	SAMPLE-2(S ₂) TABLE	29
5.3	SAMPLE-2(S ₃) TABLE	31

5.4	SAMPLE-2(S4) TABLE	33
5.5	HC EMISSION VS BP	36
5.6	CO₂ EMISSION VS BP	37
5.7	NO_x EMISSION VS BP	38
5.8	CO EMISSION VS BP	39
5.9	O₂ EMISSION VS BP	40
5.10	BTHE VS LOAD	41
5.11	SFC VS LOAD	42

LIST OF SYMBOL AND ABBREIVATIONS

O ₂	-	Oxygen
CO ₂	-	Carbon Dioxide
CO	-	Carbon Monoxide
Hc	-	Hydro Carbon
NO _x	-	Nitrogen oxides
BP	-	Load
BTHE	-	BRAKE THERMAL EFFICIENCY

CHAPTER 1

1.1 INTRODUCTION

As the world's oil supplies diminish and the effects of climate change caused by the use of fossil fuels grow more obvious, it has become imperative to create and utilise environmentally friendly, carbon-neutral energy sources. By using custard apple oil With TiO_2 as a nanoadditive. The Bio Diesel is in 1 litre of fuel it contains 800ml of diesel and 200ml of Bio Diesel and reduce smoke.

There is a big need for energy these days, and many different sources are being investigated across the globe. In light of the diminishing supply of current reserves, it became evident that new energy sources needed to be investigated, as well as ways to reduce the usage of existing ones. Consumers must be able to use the product fuel quickly and easily for any of these alternatives to be successful. Thus, this kind of fuel should be able to supply all of the world's needs. This is what we're working on right now.

Apples used to make custard are primarily a forest product, although they are also extensively farmed in India. Sit phal, Hanuman Phal, and Annona Squamosal are some of the more common local names for this plant. Custard apple seed oil was examined as a potential source of energy in today's world, where every waste material can be used to generate power. Custard apple seed oil may be used in a variety of cosmetic applications. Applied to the scalp, it promotes hair development, strengthens it, and keeps it hydrated. Premature greying of the hair is avoided. Some aromatherapy compounds utilise it as a starting point. For skin regeneration, it's an excellent choice. The skin infections may be naturally treated by this. It slows the ageing process and maintains a young appearance. Skin that is prone to breakouts will benefit from this treatment. It was noted that although there are several studies on the pulp's physical qualities [1-4], there were none that looked at the seed oil's properties. In addition, the custard apples sourced from the adjacent agency regions were not analysed for their qualities. In this research, custard apples from agency regions around Visakhapatnam

were deseeded and the oil produced from these seeds was analysed for different essential criteria. When comparing the chemical characteristics of custard apple seed oil with coconut oil and ground nut oil, the results are very similar.

Petrol (sometimes known as gas) is one of the most essential fuels for operating light motor vehicles, two-wheelers and auto rickshaws in India. Gasoline's massive usage has a significant influence on the country's import balance. As a result, any considerable decrease in the country's consumption reduces the country's import payments substantially. Because it is the world's biggest sugar producer, India has enormous potential for ethanol production via integrated molasses fermentation facilities. It is possible to make gasohol, which is chemically similar to gasoline, by mixing ethanol with the fuel. This means that gasohol may be used in place of gasoline [5]. The gasohol produced from different blends of gasoline and ethanol is put to the test for a variety of qualities in the current investigation to see whether it is suitable as a motor fuel.

1.2 BIOFUEL

“Biofuel is an inexhaustible, biodegradable fuel manufactured from Biomass.”

Biofuel is considered pure and the easiest available fuels on planet earth. Biomass, such as wood and straw, is used to make biofuels, which are then transformed into gas or liquid fuels via the process of direct combustion. The wet digestion and fermentation of organic matter such as sludge, sewage, and vegetable oils matter may also be used to produce biofuels.

Diesel engines may utilise biodiesel as an alternate fuel when petroleum-derived fuels are depleted, making it a possible alternative fuel for diesel engines.

In addition to methyl esters, biofuel may be made from raw oil. Vegetable oils, used lubricating oils, and algae are among the many bio-sources from which they are obtained. It is possible to get a wide range of biofuels from raw bio-sources such as Jatropha oil (cottonseed), palm oil, used lubricating oils and used car tyres as well as coconut oil, rapeseed oil and microalgae. Bio ethanol and bio methane may both be produced from waste biomass. It is necessary that biofuels have a standard set of physical and chemical characteristics.

The physical and chemical qualities of the biofuel generated will be affected by the transesterification process, the temperature and duration of mixing, and the quantity of catalyst or additives added to the created biofuel. The flow behavior in relation to fuel viscosity at various shear rates is an essential property (i.e., the relative velocity of the oil film between the moving parts). At high pressures and temperatures, this property impacts the spray behavior of the fuel injected into the combustion chamber.

The thickness of biofuel is equivalent to that of diesel fuel concerning temperature reliance. The rheological qualities of bio fuel generated from vegetable oils have been the subject of many earlier research. The rheological features of biofuels made from waste cooking oil, castor oil, and rubber seed oil have been investigated. They've been tested at various temperatures and shear rates, as well as compared to their original raw oils.

1.3 CUSTARD APPLE OIL

Most custard apples come from the forest, although they're also common in India. *Annona Squamosa* is the scientific name for this plant, which is known by a variety of local names including Sit phal, Hanuman Phal, and others. Custard apple seed oil was explored as a possible source of energy in today's world, when any waste item may be used to generate power. There are several cosmetic uses for custard apple seed oil. It is used to promote hair development that is stronger and more hydrated, as well as to maintain the health of the hair. It prevents hair from becoming grey too soon. Various aromatherapy compounds start with this chemical as a starting point. It's wonderful for reviving your skin. Skin infections may be naturally treated with it. It slows the ageing process and keeps the skin looking young. Pimple-prone skin will benefit from this treatment. Custard apple pulp has a plethora of published studies on its physical qualities, however custard apple seed oil studies are few and far between [1-4]. In addition, the custard apples sourced from the adjacent government regions were not tested for their qualities. These apples were sourced from agency regions around Visakhapatnam, and the oil produced from these seeds was examined for numerous essential characteristics in this research. Custard apple seed oil's chemical characteristics are compared to those of coconut oil and ground nut oil as well.

1.4 PROPERTIES OF CUSTARD APPLE OIL

Property	Value	Instrument used
Specific gravity	0.9669	Specific gravity bottle
Density	966.9 kg/m ³	Hydrometer / Density meter
Odour	Pleasant	Deodorizer
Colour	Brown	Tintometer
Viscosity	36.3 cP	Redwood viscometer
Moisture content	Zero	Hot air oven
Proximate analysis		
Moisture content	1.52 percent	Muffle furnace
Ash content	1.70 percent	Muffle furnace
Volatile matter	1.60 percent	Muffle furnace
Fixed carbon	95.16 percent	Muffle furnace

CHAPTER – 2

2.1 LITERATUR REVIEW

If you're looking for Murat Yesilyurt you've come to the right place . as a title Tests on a pressure start motor controlled by cottonseed oil biodiesel/diesel fuel combinations to research the exhibition, burning, and fumes discharge attributes. While utilizing a cottonseed oil biodiesel-diesel blend, the objective of this examination is to analyze the presentation of a diesel motor with differing parts of DEE as an oxygenated fuel added substance. In the beginning, a number of diesel and B20 mix experiments were conducted. Then. A single-cylinder, four-stroke, direct injection diesel engine was used to test all of the fuel samples under five different loads and at a set engine speed. BTE levels were reduced but BSFC levels rose when DEE was added to the mix, compared to diesel fuel. In addition, engines running on ternary mixes showed lower emissions of HC, smoke, and NOX on average than diesel engines. Although the maximum load CO emission was reduced, the CO emission trended upwards with the diesel fuel at larger proportions of DEE. As an added bonus, the CO₂ emissions decreased as well. There were noticeable changes in combustion behavior, however, when the engine was operated on all ternary mixtures. An effective use of biodiesel and diesel blends in the CI engines might be achieved using this method without considerable changes.

Muhammad Akhsin Muflikhun, Ariyana Dwiputra, and Eko Supriyanto are the members of the Indonesian team. This paper is titled The Recent Progress of Natural Source and Biodiesel Manufacturing Process. Researchers are interested in biodiesel because it has the potential to be a long-term fossil fuel alternative. In addition to being non-toxic and renewable, biodiesel has been shown to produce less hazardous pollutants to the environment, like hydrocarbons (HC), carbon monoxide (CO), and smoke particles, than petrol based diesel fuel. As a day to day fuel, biodiesel can possibly decrease ozone depleting substance (GHG) discharges, a contributing component to a dangerous atmospheric deviation. To deliver a biodiesel with

uncommon properties, considerations based on economics, agriculture, and technology should be taken while selecting natural sources of biodiesel. There is a comprehensive evaluation of the physicochemical qualities of numerous natural sources, as well as the exhibition, emanation and burning attributes of biodiesel in a diesel motor in this article. This document. Biodiesel production technologies and natural feedstocks have been studied extensively in recent years. Finally, the results of this study show that transesterification is now the best and most widely utilised process for producing biodiesel.

Duran Altiparmak, Ali Keskin, Atilla Koca, and Metin Gürü are four of the colleagues. Tall oil unsaturated fat methyl ester-diesel fuel mixes have elective fuel characteristics, as demonstrated by the title. Fuel mixes got from tall oil methyl ester and diesel were tried in this analysis. A tall oil methyl ester was made by responding tall oil unsaturated fats with methyl liquor at the right temperature and tension. Tall oil methyl ester-diesel fuel blends supported motor force and power by 6.1 percent and 5.9 percent, separately. The new fuel mixes reduced CO emissions by 38.9 percent while increasing NOx emissions by 30 percent. The smoke's opacity hardly changed.

A.S.Huzayyin A.H.Bawady M.A.Rady A.Dawood As the title proposes, this study assessed the presentation and outflows of diesel motors running on jojoba oil and diesel fuel. The high thickness of jojoba oil could cause motor issues, but it's been shown to be helpful when mixed with gas oil. The exhibition of a solitary chamber, ordinarily suctioned, direct infusion Diesel motor has been tried using gas oil and jojoba oil blends. Analyses of engine performance metrics under a variety of load settings and at various engine speeds have typically shown that mixing jojoba oil with gas oil diminishes motor NOx and ash discharges without expanding brake explicit fuel utilization. How much jojoba oil in the fuel blend has been displayed to decidedly affect motor residue outflows. Smokers. R Smit Performance, Durability and Emissions of Pure and Blended Biofuels: Compatibility. As indicated by this exploration, the similarity of unadulterated and blended biofuels concerning motor execution, sturdiness, and discharges has been inspected in a short writing survey. For the following questions, data is gathered and evaluated to look for signs of future difficulties (or advantages): In

order to achieve emission standards, will cars powered by pure biofuels or biofuel blends? Whether in pure form or as part of a mix, will biofuels be able to fulfil future fuel standards? Can additives address issues and what are the consequences of this? Will biofuels continue to outperform fossil fuels in terms of greenhouse gas emissions ? Bio-ethanol, biodiesel, virgin plant oil (VPO), Bio-FT diesel (or BTL, biomass-to-fluid), and biogas are totally remembered for the review. In this paper, Obed M. Ali and Rizalman Mamat talk about the utilization of added substances to further develop the low-temperature properties of mixed palm biodiesel. Many of the world's vast agricultural fields are underutilised. Because of this, farming should involve the production of non-food goods that are appropriate for the meteorological conditions in these regions.. As a result, biodiesel production for the domestic energy market is encouraged as a way to minimise the country's dependency on oil. The growing concern about greenhouse gas impacts and environmental restrictions has sparked a lot of interest in biodiesel research in the previous several decades. The impacts of different added substances on fuel characteristics (like thickness, cold properties, subterranean insect erosion, cetane number, heat content, instability) and motor execution are the subject of a few exploratory examination utilizing Palm Oil Methyl Ester (POME) biodiesel/diesel mixes.

CHAPTER – 3

AIM AND SCOPE OF THE PROJECT

3.1 AIM:-

The purpose of this experiment is to examine the performance of a diesel engine using a mixture of jojoba and grape seed oil.

Using low cetane number alcohols and a diesel fuel reformulation, this research aims to simultaneously reduce smoke, CO₂, CO, SO₂, NO₂, and diesel fuel emissions in order to allow a low temperature premixed combustion mode in a DI diesel engine.

3.2 SCOPE OF THE PROJECT: -

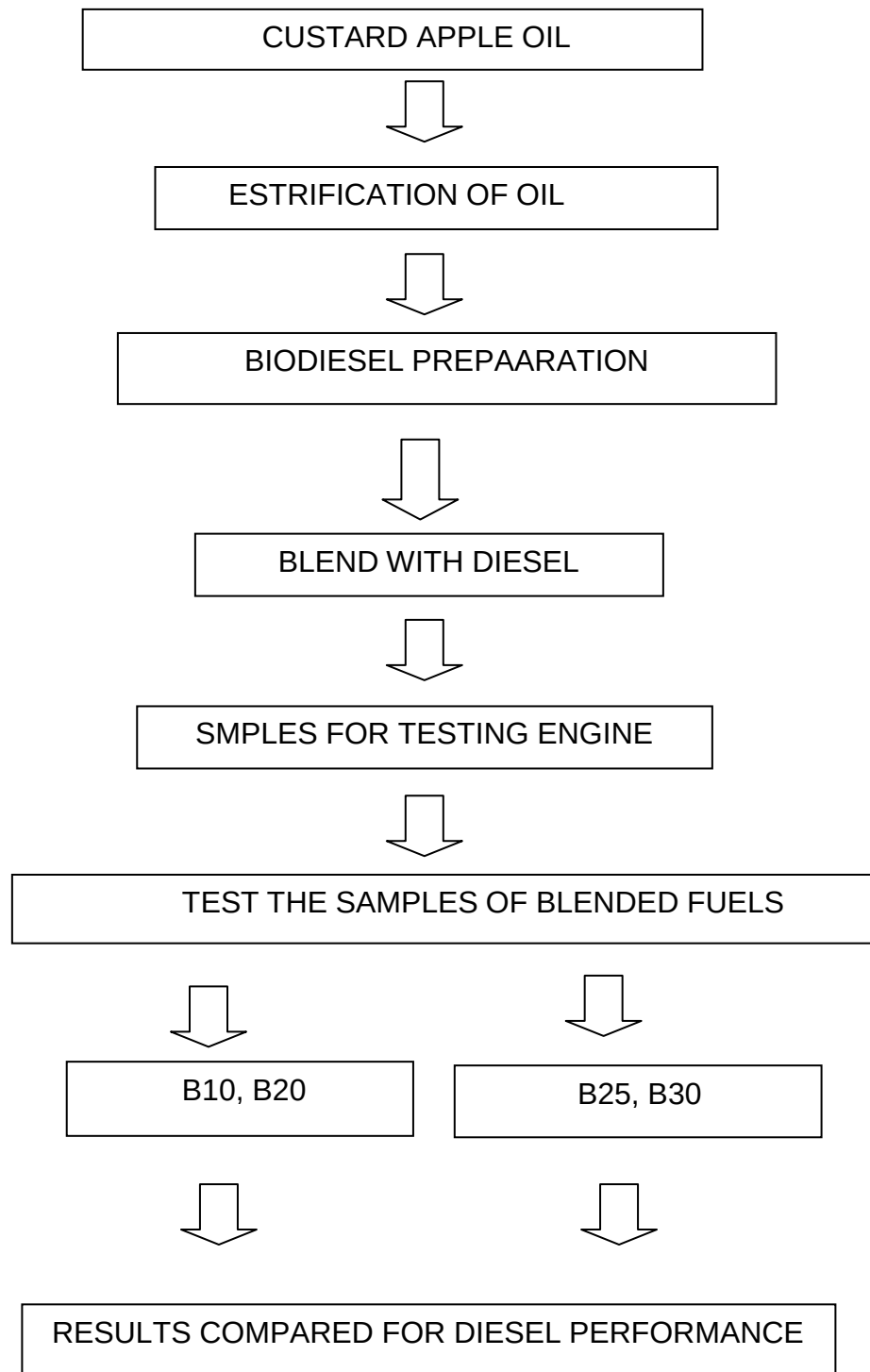
- I. To reduce the emission product
- II. Reduce smoke opacity

A solitary chamber diesel motor is being utilized to assess the biofuel's presentation at various blend proportions. The test can be conducting with diesel and jojoba, grape seed oil blends .the oil blends are making of B10, B20, B25 and B30. The fuels are used to reduce diesel requirement. Vegetables oils are easily available in world that can use for transportation and vehicle. It's becoming more important to look into biodiesel because of the diminishing supply of fossil fuels and the rising global warming consequences of combustion. There are just a few places in the globe where you can buy regular diesel gasoline. Biofuel energy is being sought by all nations and is based on readily accessible oils. Oils such as vegetable oil and animal fat, as well as recycled cooking grease, are used to create biodiesel. To lower vehicle emissions, it may be used as an additive or as a sustainable alternative fuel for diesel engines. All

components of the bioenergy production process must be simplified and enhanced to meet changing and growing global energy needs, from the design of more efficient bio refineries to the investigation into bio hydrogen as an energy carrier. In order to meet the potential of biomass for power production, current energy infrastructures need to be altered and updated. An worldwide biofuels community is being formed via the publication of review papers and original research, as well as news and development spotlights on bioenergy, interviews with important opinion leaders, as well as a host of other features.

CHAPTER - 4

4.1 METHODOLOGY



4.2 EXPERIMENTAL SET UP

Single-cylinder engines are 4-stroke, direct-injection engines. The experimental data was obtained using a Kirloskar TV1 diesel engine with a maximum output of 5.20 kW at 1500 rpm. It features a 17.5 compression ratio. To put it another way, the engine has an overall volume of 661.45 (cc), with an engine bore diameter of 87.5 mm, and an overall stroke length of 112. At all times, the injection pressure is kept constant at 210 bar.



Fig 4.1

4.3 VCR ENGINE TEST SETUP-PERFORMANCE TEST RIG

For loading, an electric start diesel engine with a variable compression ratio is coupled to an eddy current dynamometer. The engine has a single cylinder and four strokes. A shifting chamber block format permits the pressure proportion to be modified without stopping the motor or changing the burning chamber calculation. Instruments for estimating burning tension and driving rod point are remembered for the arrangement. Utilizing a motor pointer, these signs are shipped off the PC for PV charts. In addition, airflow, fuel flow, temperature, and load monitoring may all be connected.

VCR engines with EGR may be studied for braking power, indicated power, friction power, BMEP and IMEP; brake thermal efficiency, indicated thermal efficiency; mechanical efficiency; volumetric efficiency; specific fuel consumption; A/F ratio; and heat balance, among other metrics. An on-line performance assessment tool called "Engine soft" is available with a lab view. Optionally supplied is a computerized Diesel injection pressure monitoring.

4.4 Features

- Changing the CR without the engine being stopped
- There is no change to the shape of the combustion chamber.
- Water cooled EGR
- Battery and charger for electric start
- Setup for testing the mix
- In addition to P-PV graphs, performance plots, and tabular data,
- Customizable graphs with the ability to modify and publish data
- IP, IMEP, FP, and combustion analyses are all included in this

category.

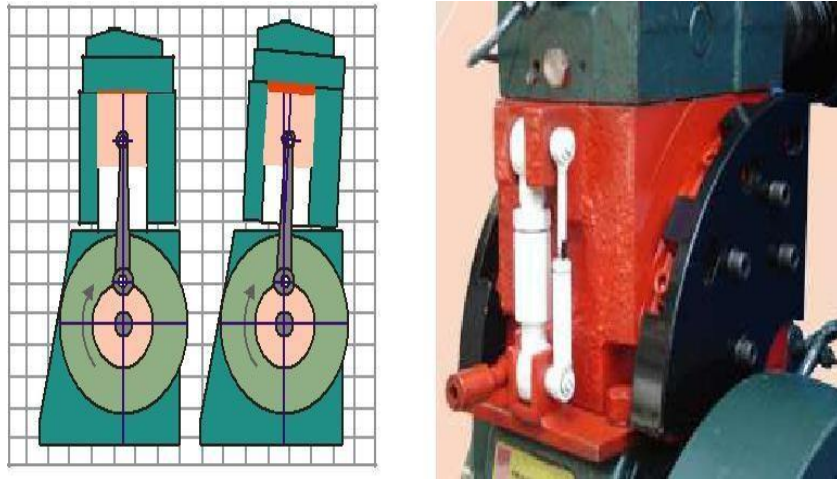


Fig. 4.2

4.5 Range of Experiments

- Study of VCR engine performance (Computerized mode)
- Study of emissions with EGR variation
- Study of combustion with different fuel blends
- Investigation of tension volume plot and showed power

4.6 Utilities

Required Electric
supply

230 +/- 10 VAC, 50 Hz, 1 phase

Water supply

Continuous, clean and soft water supply @ 1000 LPH, at 10 m. head. Providetap with 1" BSP size connection

Computer

IBM compatible with standard configuration

Software

An engine performance monitoring system created by Apex Innovations Pvt. Ltd. is called Engine Soft. Monitoring, reporting, data recording, and data entering are just some of the functions that may be provided by Engine Soft to help with engine testing. Fuel use and heat output are taken into consideration by the program. Depending on the engine, it may be customized. Operating conditions provide a variety of graphs. On-line testing of the engine in RUN mode requires the scanning, storage, and presentation of relevant data in a chart. In order to see data in graphical and tabular representations, the user opens a previously saved data file. Printouts of the data and graphics are available. For additional examination, Excel spreadsheets might be utilized.

4.7 Specifications of Engine

Table 4.1 specification of engine

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Comp.)
Product code	234
Engine	Make Kirloskar, Type 1 cyl., 4 stroke Diesel, water cooled, power 3.5kW at 1500rpm, stroke 110mm, bore 87.5mm. 661cc, CR17.5, Modified to VCR engine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer

Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC

Optional	Computerized Diesel injection pressure measurement with injection variation 0-25 deg BTDC
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Piezo powering unit	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100oC,3 Nos; Thermocouple, Range 0-1200 O ₂ , 2 Nos

EMISSION TEST RIG

The following Gas values can measured

4.8 GAS ANALYZER

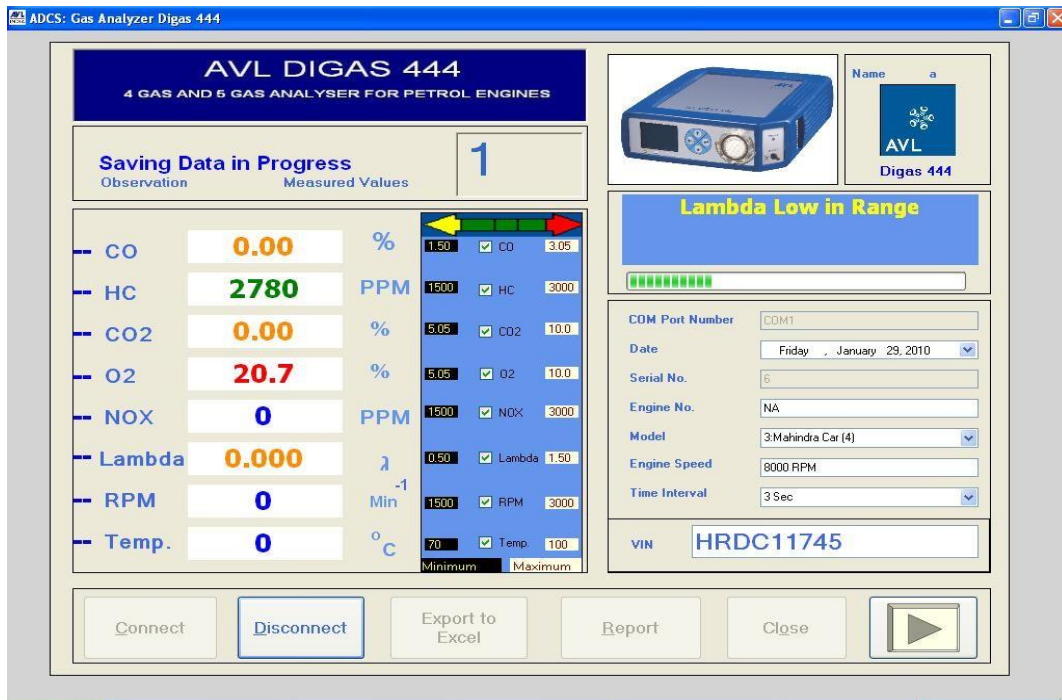


Fig.4.3

- Gas analyser shows the emissions from the combustion
- Gas analyser are used for measuring CO, CO2, HC, NO, NOX&O2 gases from emission measurements from ppm to percentage
- Gas analyser are widely used in various applications such as boilers, furnaces exhaust emission gases and the efficiency of combustion monitoring.

MOKEMETER 437 STD/ SMOKEMETER 437 C

Table 4.2

Type	AVL 437 Smoke meter Make
Make	AVL India Private Limited
Measuring range	0 to 100 HSU (Hat ridge Smoke units)
Smoke Temperature	2500 C (Maximum at entrance)
Ambient temperature	0 to 50°C
Humidity	90% at 50°C (Non conditioning)
Power Supply	205 A, 11.5 -36V DC
Principle	Light absorption principle



Fig. 4.4



Fig. 4.5

- A smoke opacity metre is a diagnostic tool for diesel engines that measures the level of opacity in the exhaust.
- Opacity metres measure the amount of light that is obscured by the smoke from diesel engines in vehicles such as automobiles, motorcycles, and ships.
- The smoke metre reading shows the density of the smoke, which is a measure of combustion efficiency.

4.9 SAMPLE PREPARATION



Fig. 4.6

4.9.1 SAMPLES OF CUSTARDAPPLEOIL

Table 4.3 sample of custard apple oil

SAMPLE	CUSTARD APPLE OIL	DIESEL
S1	90%	10%
S2	80%	20%
S3	75%	25%
S4	70%	30%

4.10 EXPERIMENTAL WORK

Samples of biodiesel blends have been made and are ready to be tested. Using a venturimeter, the biodiesel samples are connected to a diesel pump and tested in an engine. There was testing and samples were collected one at a time. The 437C smoke meter was used for emission testing, and readings were obtained from the meter. To get the most accurate measurements, a variety of load tests were performed on the engine.

4.11 EMISSION GASES

EMISSION OF CO GAS

Carbon monoxide may be dangerous if it is inhaled for an extended period of time in a confined environment, even though diesel engines emit lower quantities of CO than gasoline engines. Diesel exhaust gases may include anything from 2% to 12% carbon monoxide. When the oxidation process does not finish entirely, carbon monoxide is produced. Air/fuel combination is a major component in determining this concentration, and it is maximum when the excess-air factor is less than 1.0. Particularly during engine startup and acceleration, when high mixes are necessary, it might occur. There is not enough air and reactant concentration to convert all the carbon to CO₂ and generate CO concentration in the rich mixes. A limited amount of CO is exhaled under lean circumstances due to chemical kinetic effects, despite the fact that CO is created during operation in rich mixes.

Lean combustion engines, such as those used in diesel engines, have a high air–fuel ratio. Diesel engines, on the other hand, produce very little carbon dioxide. In spite of this, CO might be shaped in a diesel motor when the drops are too enormous or the burning chamber isn't sufficiently fierce.

Carbon monoxide is a colorless, odorless gas that is difficult to detect. Airborne CO is taken in via the nose and mouth by the lungs, where it is absorbed into the circulation. It interferes with the ability of hemoglobin to transport oxygen. Airborne carbon dioxide (CO) levels may have an impact on the operation of several organs, resulting in reduced concentration and delayed reflexes as well as disorientation.

4.12 EMISSION OF HC GAS

Hydrocarbon emissions are made up of unburned fuels due to the lack of heat near the cylinder wall, which results in hydrocarbon emissions. Air–fuel mixture temperature is lower than cylinder center at this moment (Demers and Walters 1999; Correa and Arbilla 2008). Alkanes, alkenes, and aromatics are only a few of the hundreds of hydrocarbon species. Equivalent CH₄ content is the most common way of describing them. Hydrazine outflows from diesel motors are ordinarily very low. At low loads, diesel hydrocarbon outflows are the most widely recognized wellspring of contamination. Lean air-fuel blending is the essential wellspring of light-load hydrocarbon outflows. As a result, substantial levels of hydrocarbon emissions are produced in lean mixes when flame speeds are either too low or nonexistent to allow for full combustion throughout the power stroke. To varying degrees, the hydrocarbon concentration in diesel engines may be affected by the kind of fuel, engine setup, and engine design used. Due to erratic operating circumstances, emissions of hydrocarbons (HCs) in exhaust gas might vary. Rapid acceleration and deceleration of the engine's speed might result in a substantial amount of unburned gasoline being released into the exhaust. At temperatures over 600 C and with oxygen present, unburned hydrocarbons will continue to react in the exhaust, resulting in hydrocarbon emissions from the tailpipe that are much lower than those coming out of the cylinder itself. Hydrocarbon emanations happen in the vehicle fumes, yet in addition in the motor crankcase, the fuel framework, and from the encompassing venting of fumes during gas circulation and apportioning.

Concerning generally hydrocarbon outflows, crankcase hydrocarbon discharges and evaporative misfortunes of hydrocarbon emanations, individually, represent 20-35 and 15-25 percent, while tailpipe hydrocarbon emanations contain 50-60 percent.

The environment and human health are both negatively affected by hydrocarbons' presence. They have a crucial role in the generation of ground-level ozone in combination with other pollutants. About half of the pollutants that result in ozone are caused by automobiles. Hydrocarbons have the potential to induce respiratory tract irritation and cancer, and should be avoided at all costs.

4.13 EMISSION OF NOX GAS

Fuel is lighted in a diesel motor by utilization of an exceptionally compacted stream of hot air. The burning chamber is initially loaded up with oxygen and nitrogen-rich air. When the air in the ignition chamber arrives at generally the highest point of the pressure stroke, the fuel is infused straight into it. The hotness is produced because of the consuming of the fuel. Ordinary burning remembers no responses between nitrogen for the air and oxygen in the ignition chamber, in this way the two gases are ousted likewise from that point. Nitrogen reacts with oxygen when heated over 1,600 C in the cylinders, resulting in NO_x emissions. It's probably correct that the temperature and oxygen content in the burning are the two most significant variables in deciding the formation of NO_x. Temperature, oxygen concentrations, and duration in the cylinder are all factors that influence the quantity of NO_x created. Whenever the cylinder is at the pinnacle of its stroke, most of the NO_x emanations are delivered. Temperatures are maximum during this time period. Three times as much NO_x is produced for every 100 C rise in combustion temperature. There are two types of nitrogen oxides: NO and N₂O. (NO₂). 85–95 percent of NO_x is made up of NO. In the atmosphere, it slowly transforms into NO₂. NO_x is a catch-all term for both NO and NO₂, however the two pollutants have their own unique properties. NO₂ is a reddish brown gas with a distinct odor, while NO is colorless and odorless. The majority of urban NO_x emissions come from road transportation, which accounts for 40–70 percent of the total. Diesel cars are the most significant contributors to NO_x emissions

among other kinds of vehicles. These engines need greater temperatures to start since they are compression-ignited. About 85% of all mobile sources' NO_x emissions are attributed to diesel engines, mostly as NO.

Vehicles' nitrogen oxide discharges are a significant wellspring of contamination and wellbeing gambles for the climate and individuals. Fermentation, ozone creation, supplement enhancement, and brown haze arrangement are totally aggravated by NO_x discharges, which are presently a genuine worry in most of the world's biggest urban areas. Through substance responses with different poisons in the environment, nitrogen oxide (NO_x) emanations produce tropospheric ozone (the significant part of photochemical brown haze). NO and NO₂ are both respected hurtful, yet NO₂ has a harmfulness edge multiple times bigger than that of NO and is an immediate issue for human lung sickness. Respiratory infections may be worsened if one breathes nitrogen dioxide, which irritates the lungs (such as influenza). Acid rain may have a devastating effect on both terrestrial and aquatic ecosystems because of NO_x emissions. The pollution haze that reduces vision is also caused by nitrogen dioxide and nitrates in the air.

4.14 EMISSION OF CO₂ GAS

It is one of the most challenging problems of the energy transition to reduce CO₂ emissions from the transportation industry. An excellent way to replace fossil fuel-based transportation is, of course, to electrify automobiles. Despite these drawbacks, this route is still recommended to some extent dictated by the battery's capacity density. Because fossil fuels have a limited supply, they must be replaced with biofuels. Fossil fuels should be phased out entirely. A large amount of land is needed to do so, which might put food production at risk. Another option is to use renewable power to absorb CO₂ and convert it to fuels. This can be done with little energy penalty, though. CO₂ emissions are mostly a result of the usage of fossil fuels. Deforestation, land clearance for agriculture, and soil degradation all contribute to the emission of CO₂ directly from human activity. Similarly, reforestation, soil improvement, and other activities may remove CO₂ from the atmosphere.

4. 15 EMISSION OF O₂ GAS

Oxygen analyzers installed between the engine's air box and intake manifold measure the engine's oxygen content. The test motor is associated with a Magtrol (model-4WB15)- swirl current dynamometer. Notwithstanding the mass equilibrium, which estimated fuel stream rate, a bomb calorie meter was utilized to gauge the calorific worth of fuel, a thermocouple to screen the temperature of fumes gas, consumption air and a TDC marker (an attractive pickup), and a rpm pointer were utilized. A Kistler piezo electric transducer identifies the ignition chamber pressure (a mean worth of 50 sequential cycles) utilizing an AVL information assortment framework (AVL indicom minimal). HORIBA MEXA 548L five gas analyzer was utilized to test fumes gases, which are analyzed using the non-dispersive infrared principle. Carbon monoxide (CO) with a precision of 0.01 percent is measured by the Analyzer, which has an accuracy of 1 ppm for nitrogen oxides and total unburned hydrocarbons. AVL smoke meters of type AVL 437C can measure the opacity of smoke with a range of zero to 99.99 percent of smoke opacity, with a precision of 0.01 percent.

Oxygen enrichment has been shown to significantly reduce smoke density in the exhaust, which is an encouraging outcome. Sediment molecule accumulation in diesel fumes is the essential driver of smoke in a diesel motor. Fuel hydrocarbons and lubricating oil both contribute to the formation of this toxic gas. The stoichiometry, temperature, pressure, and mixing are all critical factors in the creation of soot. Soot in the exhaust gas is dominated by the generation and oxidation of soot in the combustion process. Increased oxygen-to-fuel ratio increases fuel oxidation and reduces soot formation is a primary benefit of oxygen enrichment. Oxygen advancement likewise diminishes the start delay, bringing about expanded consuming rate and a more limited ignition length. Altogether decreasing sediment creation. At full burden with 27% oxygen enhancement, the least decline in smoke obscurity because of oxygen advancement is 15%, while the most extreme decrease is 60% at no heap with 27% oxygen improvement. Smoke opacity levels are consistently reduced at all loads and oxygen concentrations as described.

CHAPTER – 5

5.1 Sample 1 (S1)

Report Date : Mon, Feb 21, 2022, Time : 1:39:26 PM

Organization: Organization, Operator : Operator

Data File: S1 .xlsx, Last Modified Date: Thu, Feb 17,2022,

Config. File: Research Diesel Engine.xls

Engine Details:

The ICE engine under test is a research diesel with a power of 3.50 kW @ 1500 rpm, single cylinder, four stroke, constant speed, water cooled, diesel engine, cylinder bore 87.50 (mm), stroke length 110.00 (mm), connecting length Rod 234.00 (mm), compression ratio 17.50, scan volume 661.45 (cc)

Combustion parameters:

Gas Specification (kJ / kg): 1.00, Air Density (kg / m ^ 3): 1.17, Adiabatic Index: 1.41, Multi-Feed Index: 1.33, Cycle Count: 10, Cylinder Pressure Reference: 7, Smooting 2, TDC Reference: -11

Performance Parameters:

Orifice Diameter (mm): 20.00, Orifice Coeff. Of Discharge: 0.60, Dynamometer Arm Legnth (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) : 830, Calorific Value Of Fuel (kj/kg) : 42000

Table 5.1 sample 1 results

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)
1564	0.36	17.50	34.81	38.46	34.81	34.14	184.47	154.62
1550	3.21	17.50	34.81	37.90	34.81	33.91	178.58	148.12
1536	6.26	17.50	34.81	38.06	34.81	33.95	188.54	150.70
1515	9.21	17.50	34.80	38.65	34.81	34.20	208.39	160.83

Observation Data

Air (mmWC)	Fuel (cc/min)	WaterFlow Engine (lph)	WaterFlow Cal (lph)
312.92	9.00	150	100
312.90	12.00	150	100
312.92	15.00	150	100
312.91	19.00	150	100

Result Data

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.65	0.11	4.65	4.76	0.12	5.52	2.04	90.97	2.24
5.83	0.95	4.72	5.67	1.11	6.63	13.58	81.30	16.71
11.36	1.83	5.22	7.04	2.16	8.32	20.97	80.81	25.95
16.71	2.65	5.72	8.37	3.18	10.03	24.02	75.86	31.67

Result Data

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kW h)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
57.61	0.45	4.21	158.12	128.53	2.04	12.17	53.42	32.37
57.61	0.60	0.63	159.55	96.40	13.58	7.74	38.67	40.01
57.61	0.75	0.41	161.01	77.12	20.97	6.50	33.05	39.48
57.61	0.95	0.36	163.24	60.88	24.02	6.08	29.40	40.50

5.2 Sample 2 (S2)

Report Date : Mon, Feb 21, 2022, Time : 1:41:20 PM

Organization: Organization, Operator : Operator

Data File: S2 .xlsx, Last Modified Date: Thu, Feb 17,2022,

Config. File: Research Diesel Engine.xls

Table 5.2 sample 2 results

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)
1566	0.16	17.50	34.78	39.57	34.78	34.75	211.59	170.91
1552	3.41	17.50	34.77	38.50	34.78	34.26	194.03	159.51
1539	6.24	17.50	34.78	38.27	34.78	34.13	195.64	156.76
1521	9.10	17.50	34.79	38.75	34.80	34.32	211.84	164.48
1497	12.08	17.50	34.79	39.30	34.79	34.55	230.28	174.21
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Observation Data

Air (mmWC)	Fuel (cc/min)	WaterFlow Engine (lph)	WaterFlow Cal (lph)
312.93	0.00	150	100
312.94	12.00	150	100
312.93	15.00	150	100
312.92	16.00	150	100
312.91	22.00	150	100
0.00	0.00	0	0

Result Data

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.29	0.05	4.58	4.62	0.06	5.36	0.00	0.00	1.03
6.18	1.00	4.72	5.72	1.17	6.69	14.41	82.04	17.57
11.33	1.83	3.82	5.64	2.15	6.59	20.96	64.73	32.37
16.52	2.63	4.39	7.02	3.14	8.28	28.30	75.56	37.45
21.93	3.44	4.96	8.40	4.17	10.01	26.89	65.68	40.95
0.00	0.00	2.79	2.79	NaN	3.38	0.00	0.00	0.00

Result Data

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kW h)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
57.61	0.00	0.00	157.92	0.00	0.00	0.00	0.00	100.00
57.61	0.60	0.59	159.35	96.40	14.41	9.33	42.61	33.65
57.61	0.75	0.41	160.69	77.12	20.96	6.98	34.50	37.56
57.61	0.80	0.30	162.59	72.30	28.30	7.42	35.48	28.80
57.61	1.10	0.32	165.20	52.58	26.89	6.16	28.53	38.42
0.00	0.00	0.00	NaN	0.00	0.00	0.00	0.00	100.00

5.3 Sample 3 (S3)

Report Date : Mon, Feb 21, 2022, Time : 1:44:34 PM
Organization: Organization, Operator : Operator
Data File: S3 .xlsx, Last Modified Date: Thu, Feb 17,2022,
Config. File: Research Diesel Engine.xls

Table 5.3 sample 3 results

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)
1566	0.10	17.50	34.81	38.82	34.81	34.45	193.94	162.73
1551	3.34	17.50	34.82	38.13	34.82	34.16	186.24	154.21
1538	6.52	17.50	34.81	38.21	34.81	34.18	194.96	156.46
1519	9.28	17.50	34.81	38.69	34.81	34.34	211.20	163.99
1497	12.19	17.50	34.81	39.33	34.81	34.60	232.27	175.44

Observation Data

Air (mmWC)	Fuel (cc/min)	WaterFlow Engine (lph)	WaterFlow Cal (lph)
312.91	9.00	150	100
312.91	12.00	150	100
312.93	16.00	150	100
312.94	19.00	150	100
312.92	20.00	150	100

Result Data

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.17	0.03	4.60	4.63	0.03	5.36	0.55	88.51	0.62
6.07	0.99	4.72	5.71	1.15	6.67	14.13	81.84	17.27
11.83	1.91	5.25	7.15	2.25	8.44	20.50	76.95	26.64
16.84	2.68	5.75	8.43	3.20	10.06	24.27	76.33	31.80
22.13	3.47	6.23	9.70	4.20	11.75	29.85	83.44	35.78

Result Data

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kW h)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
57.61	0.45	15.69	157.92	128.53	0.55	13.36	56.63	29.46
57.61	0.60	0.61	159.45	96.40	14.13	8.30	40.62	36.95
57.61	0.80	0.42	160.80	72.30	20.50	6.38	32.24	40.87
57.61	0.95	0.35	162.81	60.89	24.27	6.13	29.86	39.74
57.61	1.00	0.29	165.20	57.84	29.85	6.79	31.63	31.73

5.4 Sample 4 (S4)

Report Date : Mon, Feb 21, 2022, Time : 1:52:13 PM
Organization: Organization, Operator : Operator
Data File: S4 .xlsx, Last Modified Date: Thu, Feb 17,2022,
Config. File: Research Diesel Engine.xls

Table 5.4 sample 4 results

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)
1566	0.14	17.50	34.82	39.18	34.83	34.58	199.65	165.22
1552	3.26	17.50	34.81	38.05	34.82	34.03	180.51	150.03
1537	6.27	17.50	34.82	38.11	34.82	34.08	188.85	152.13
1519	9.11	17.50	34.82	38.60	34.82	34.26	206.04	160.04
1498	11.96	17.50	34.82	39.42	34.82	34.58	229.86	173.70

Observation Data

Air (mmWC)	Fuel (cc/min)	WaterFlow Engine (lph)	WaterFlow Cal (lph)
312.91	4.00	150	100
312.93	12.00	150	100
312.92	16.00	150	100
312.90	19.00	150	100
312.93	22.00	150	100

Result Data

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.25	0.04	4.58	4.62	0.05	5.36	1.77	198.93	0.89
5.92	0.96	4.76	5.72	1.12	6.69	13.80	82.03	16.82
11.38	1.83	5.66	7.49	2.16	8.84	19.70	80.54	24.46
16.54	2.63	5.77	8.40	3.14	10.03	23.83	76.06	31.33
21.70	3.40	6.27	9.68	4.12	11.72	26.63	75.69	35.18

Result Data

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
57.61	0.20	4.85	157.92	289.19	1.77	32.68	131.22	0.00
57.61	0.60	0.62	159.35	96.40	13.80	8.10	39.16	38.94
57.61	0.80	0.44	160.90	72.30	19.70	6.19	31.07	43.04
57.61	0.95	0.36	162.80	60.88	23.83	5.97	29.02	41.18
57.61	1.10	0.32	165.09	52.58	26.63	6.29	28.47	38.62

5.5 HC EMISSION VS BP (KW) GRAPH

Table 5.5 HC emission vs BP graph

	0	0.875	1.75	2.62	3.5
S1	1	4	5	8	13
S2	3	5	8	11	12
S3	5	8	10	13	16
S4	5	7	9	11	13
Diesel	2	6	10	15	19

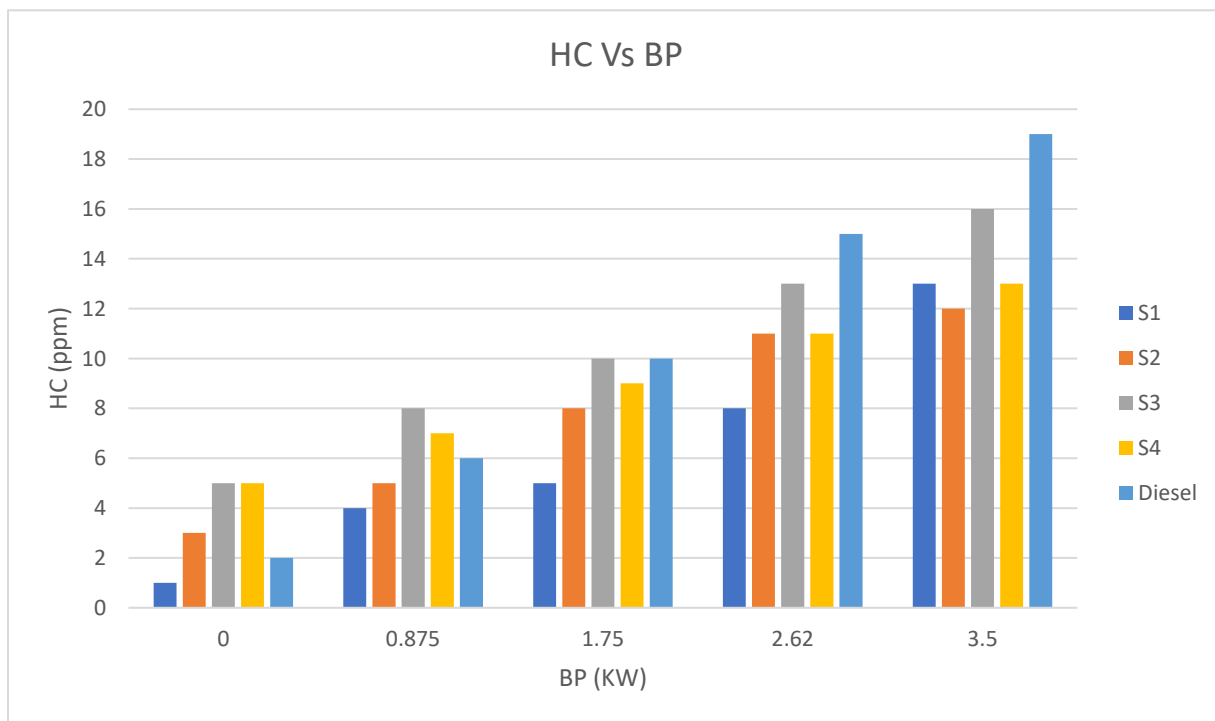


Fig 5.1 HC emission vs bp

For sample S1 at minimum load 0.0875 KW the HC emission is 4 and for maximum load the HC emission is 13. For sample S2 at minimum load 0.0875 KW the HC emission is 5 and for maximum load the HC emission is 12. For sample S3 at minimum load 0.0875 KW the HC emission is 8 and for maximum load the HC emission is 16. For sample S4 at minimum load 0.0875 KW the HC emission is 7 and for maximum load the HC emission is 13.

5.6 CO₂ EMISSION VS BP (KW) GRAPH

Table 5.6 CO₂ emission vs BP graph

	0	0.875	1.75	2.62	3.5
S1	0.7	1.2	1.95	1.9	2.3
S2	0.6	1.3	1.45	1.9	2.1
S3	0.8	1.3	1.7	2.1	2.2
S4	1.2	1.3	1.7	2.1	2.5
Diesel	1.6	1.96	2.54	2.89	2.98

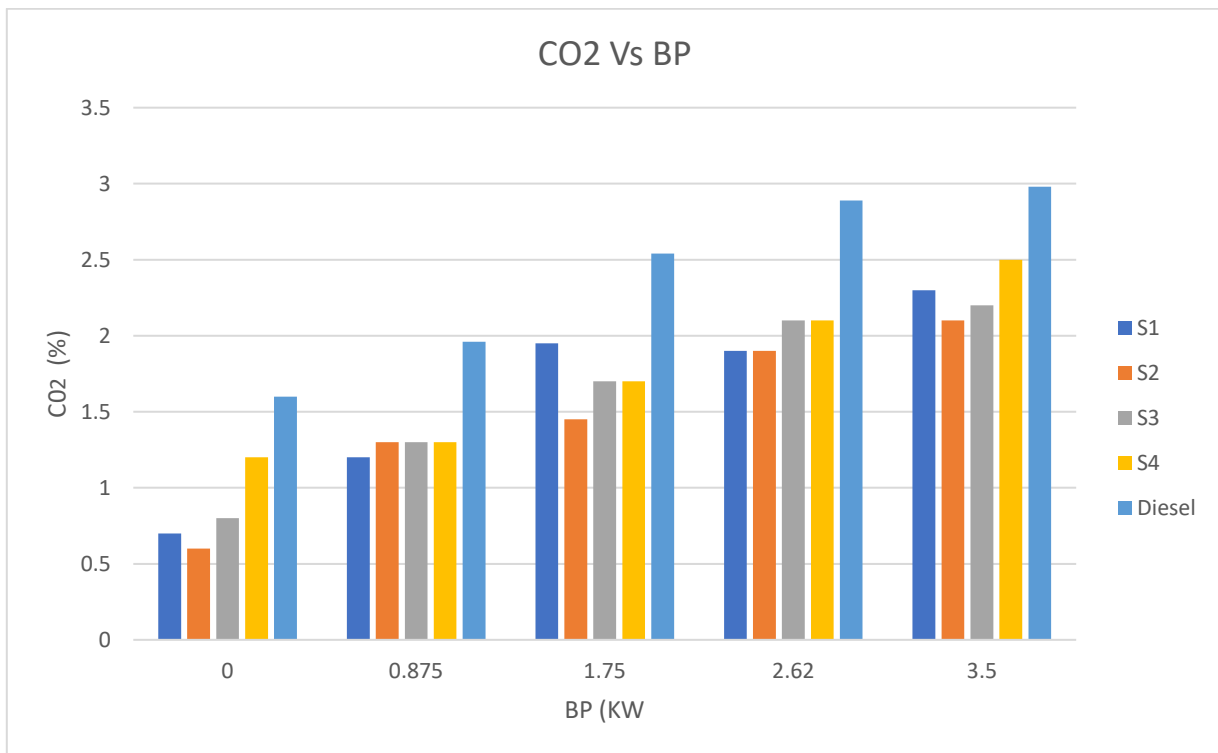


Fig 5.2 CO₂ vs bp

For sample S1 at minimum load 0.0875 KW the CO₂ emission is 1.2 and for maximum load the CO₂ emission is 2.3. For sample S2 at minimum load 0.0875 KW the CO₂ emission is 1.3 and for maximum load the CO₂ emission is 2.1. For sample S3 at minimum load 0.0875 KW the CO₂ emission is 1.3 and for maximum load the CO₂ emission is 2.2. For sample S4 at minimum load 0.0875 KW the CO₂ emission is 1.3 and for maximum load the CO₂ emission is 2.5.

5.7 NOx EMISSION VS BP (KW) GRAPH

Table 5.7 NOx emission vs BP graph

	0	0.875	1.75	2.62	3.5
S1	102	193	248	317	452
S2	105	198	203	265	347
S3	87	157	212	301	399
S4	103	189	235	312	387
Diesel	56	156	289	485	750

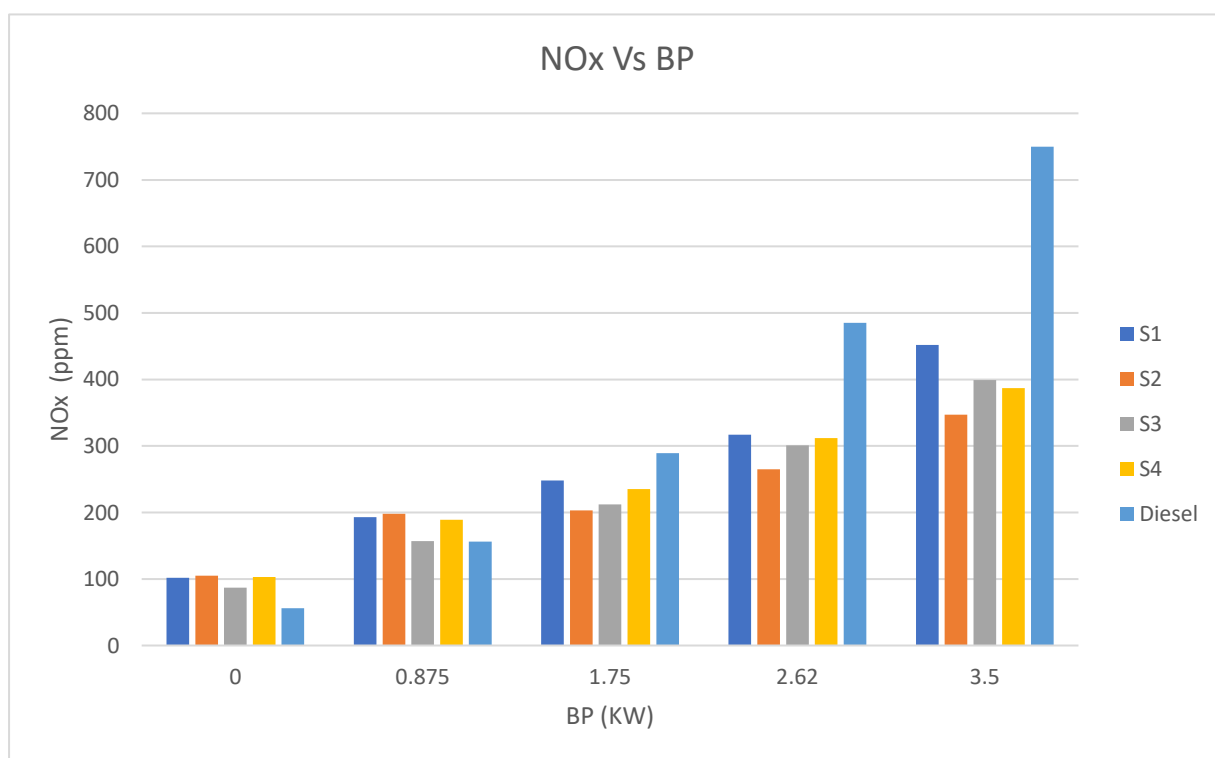


Fig 5.3 NOx vs bp

For sample S1 at minimum load 0.0875 KW the NOX emission is 198 and for maximum load the NOX emission is 452. For sample S2 at minimum load 0.0875 KW the NOX emission is 198 and for maximum load the NOX emission is 347. For sample S3 at minimum load 0.0875 KW the NOX emission is 157 and for maximum load the NOX emission is 399. For sample S4 at minimum load 0.0875 KW the NOX emission is 189 and for maximum load the NOX emission is 387.

5.8 CO₂ EMISSION VS BP (KW) GRAPH

Table 5.8 CO₂ emission vs bp graph

	0	0.875	1.75	2.62	3.5
S1	0.01	0.023	0.027	0.032	0.041
S2	0.013	0.023	0.032	0.041	0.057
S3	0.02	0.031	0.041	0.048	0.053
S4	0.019	0.024	0.031	0.038	0.042
Diesel	0.008	0.013	0.018	0.023	0.029

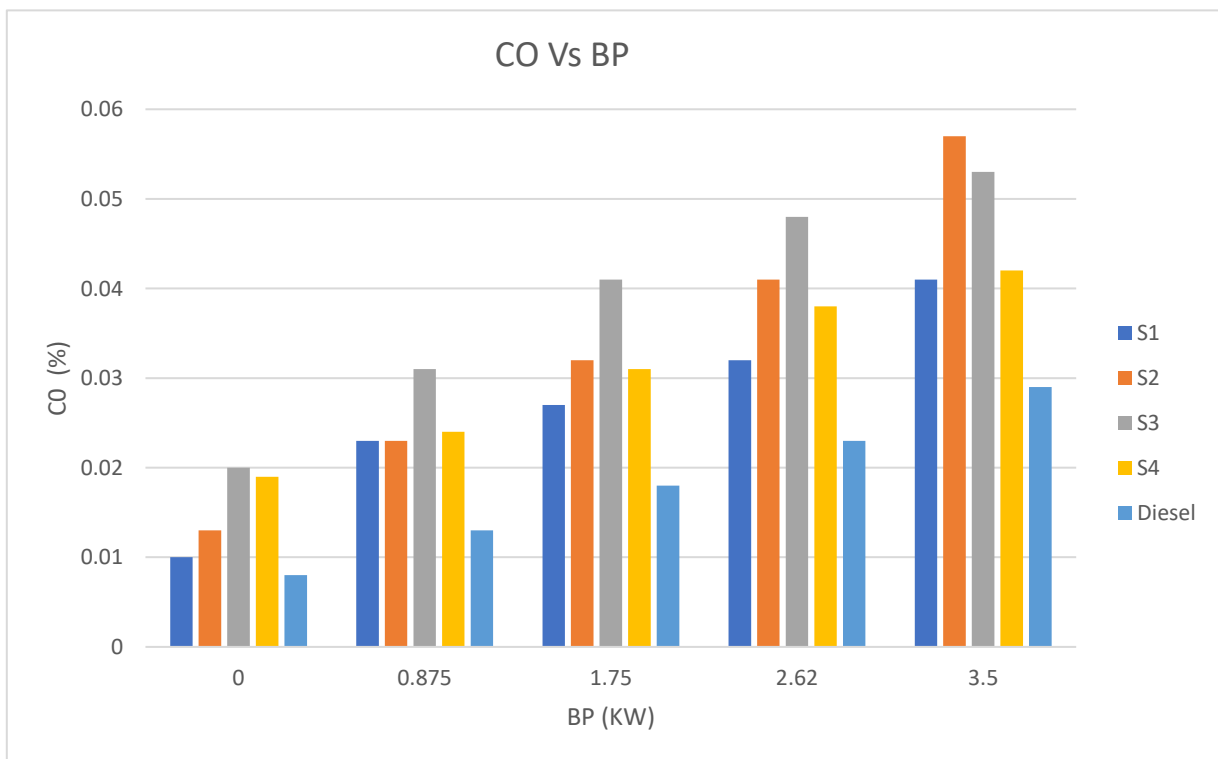


Fig 5.4 CO vs bp graph

For sample S1 at minimum load 0.0875 KW the CO emission is 0.023 and for maximum load the CO emission is 0.041. For sample S2 at minimum load 0.0875 KW the CO emission is 0.023 and for maximum load the CO emission is 0.057. For sample S3 at minimum load 0.0875 KW the CO emission is 0.031 and for maximum load the CO emission is 0.053. For sample S4 at minimum load 0.0875 KW the CO emission is 0.024 and for maximum load the CO emission is 0.042.

5.9 O2 EMISSION VS BP (KW) GRAPH

Table 5.9 O2 emission vs bp graph

	0	0.875	1.75	2.62	3.5
S1	19.74	18.92	18.16	17.58	16.8
S2	19.89	19.17	18.98	17.76	17.17
S3	19.31	19.02	18.78	18.03	17.58
S4	19.31	18.78	18.27	18.56	17.32
Diesel	18	19	15	12	11

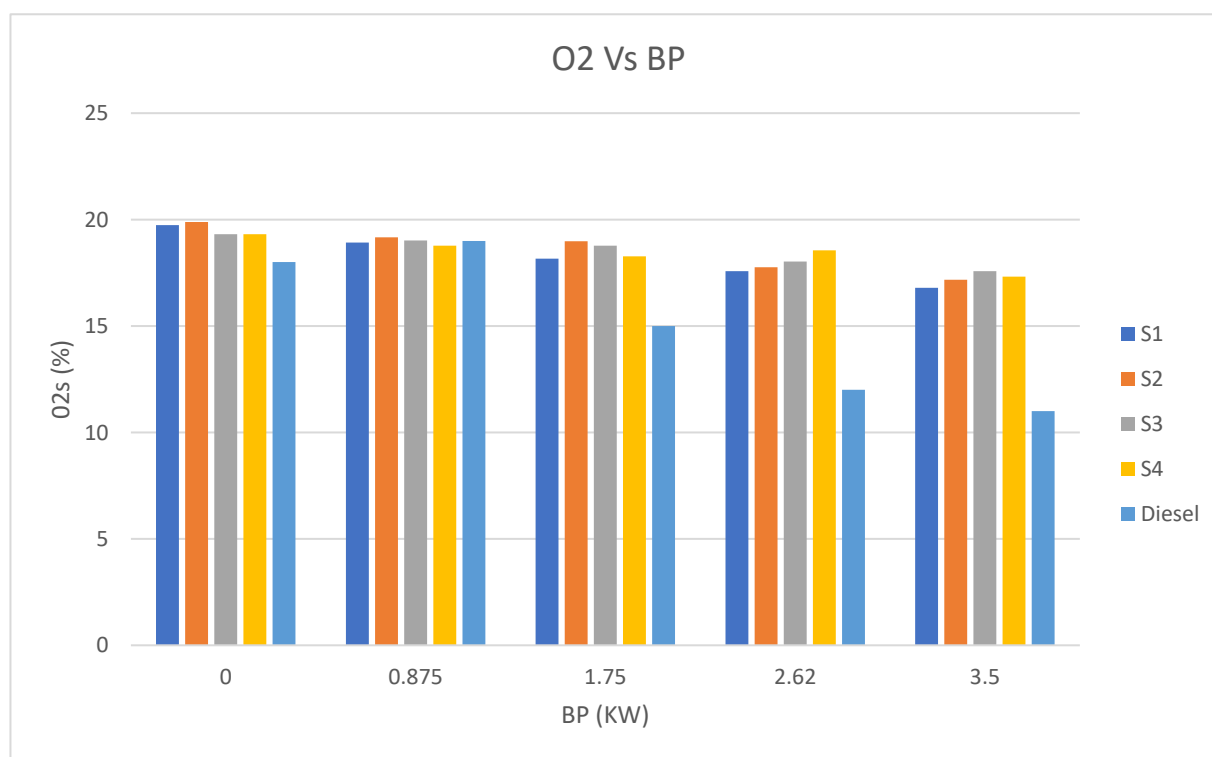


Fig 5.5 O2 vs Bp

For sample S1 at minimum load 0.0875 KW the O2 emission is 18.92 and for maximum load the O2 emission is 16.8. For sample S2 at minimum load 0.0875 KW the O2 emission is 19.17 and for maximum load the O2 emission is 17.17. For sample S3 at minimum load 0.0875 KW the O2 emission is 19.02 and for maximum load the O2 emission is 17.58. For sample S4 at minimum load 0.0875 KW the O2 emission is 18.78 and for maximum load the O2 emission is 17.32.

5.10 BTHE VS LOAD GRAPH

TABLE 5.10 BTHE vs Load

	0	0.875	1.75	2.62	3.5
S1	0	2.04	13.58	20.97	24.02
S2	0	14.41	20.96	28.3	26.89
S3	0	0.55	14.13	20.5	24.27
S4	0	1.77	13.8	19.7	23.83
Diesel	0	16.49	22.75	29.47	32.59

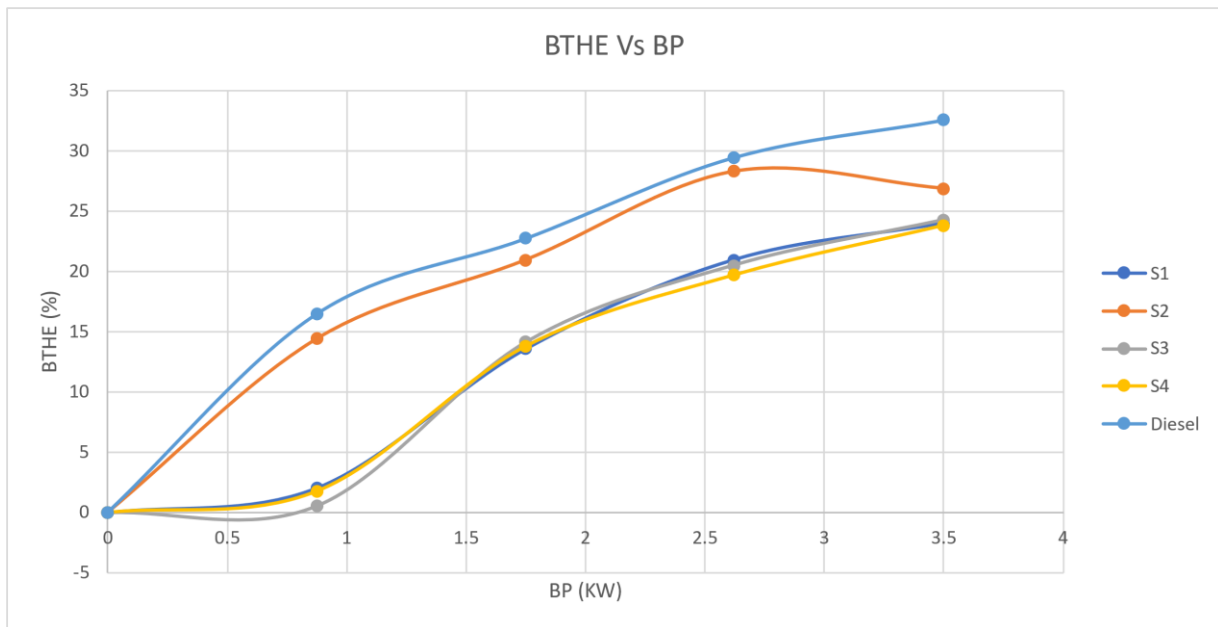


Fig 5.6 BTHE VS BP

For sample S1 at minimum load 0.0875 KW the BTHE is 2.04 and for maximum load the BTHE is 24.02. For sample S2 at minimum load 0.0875 KW the BTHE is 14.41 and for maximum load the BTHE is 26.89. For sample S3 at minimum load 0.0875 KW the BTHE is 0.55 and for maximum load the BTHE is 24.27. For sample S4 at minimum load 0.0875 KW the BTHE is 1.77 and for maximum load the BTHE is 23.83.

5.11 SFC VS LOAD GRAPH

Table 5.11 SFC vs load graph

	0	0.875	1.75	2.62	3.5
S1	4.21	0.63	0.41	0.36	0
S2	0.59	0.41	0.3	0.32	0
S3	15.69	0.61	0.42	0.35	0.29
S4	4.85	0.62	0.44	0.36	0.32
Diesel	3.45	0.52	0.38	0.29	0.2

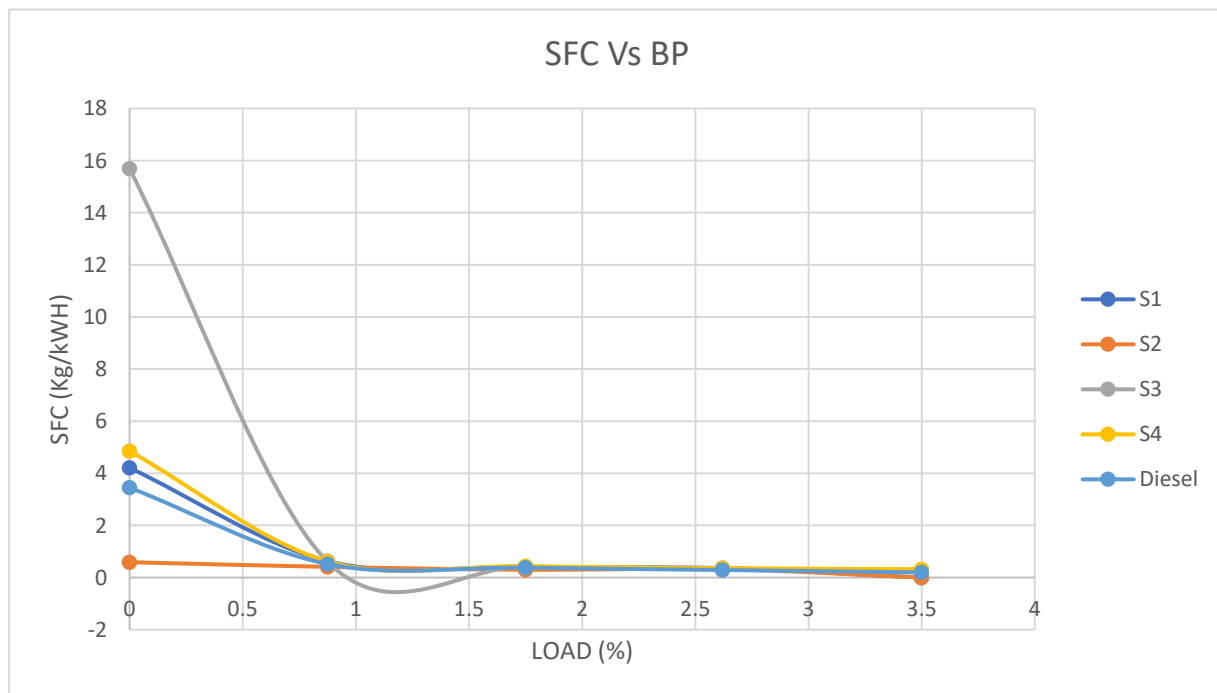


Fig 5.7 SFC vs bp

For sample S1 at minimum load 0.0875 KW the SFC is 0.63 and for maximum load the SFC is 0. For sample S2 at minimum load 0.0875 KW the SFC is 0.41 and for maximum load the SFC is 0. For sample S3 at minimum load 0.0875 KW the SFC is 0.61 and for maximum load the SFC is 0.29. For sample S4 at minimum load 0.0875 KW the SFC is 0.62 and for maximum load the SFC is 0.32.

5.11 RESULTS AND DISCUSSIONS

5.12 RESULTS

One sample at a time was put into a container linked to the venturimeter on the front of the engine pump and the biodiesel made from custard apple oil biodiesel was analysed. You can see precisely how much gasoline is being fed into the engine by using the venturimeter. A smoke metre is fitted to the exhaust to measure the quantity of pollutants produced. Graphs are used to compare the outcomes of each of the blends.

5.13 Result Data –Pure Diesel

Table 5.12 result data pure diesel

Torque (Nm)	BP (kW)		FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
1.11	0.00		1.23	1.28	0.21	1.50	2.45	24.40	14.14
6.55	0.875		0.88	1.75	1.24	2.29	16.49	30.33	54.37
11.56	1.75		0.78	2.53	2.20	3.12	22.75	32.37	70.29
17.52	2.62		0.61	3.22	3.33	4.06	31.71	38.72	81.90
22.42	3.5		0.43	3.93	4.26	4.78	32.59	35.46	89.10

5.14 Result Data –Pure Diesel

Table 5.13 result data pure diesel

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
30.24	0.45	2.48	83.96	67.46	3.45	0.00	26.84	69.71
30.05	0.55	0.52	83.99	54.86	16.49	0.00	22.00	61.51
29.62	0.70	0.38	83.16	42.48	22.75	0.00	18.95	58.29
29.00	0.75	0.29	82.65	38.82	31.71	0.00	19.66	48.63
28.54	0.95	0.20	82.50	30.16	31.59	0.00	17.87	50.54

5.15 Emission Details for 3.5 KW Diesel Engine

Table 5.14 emission detail for 3.5 kW diesel engine

Load (kw)	HC (PPM)	CO(%)	CO2(%)	O2(%)	NOx(PPM)
0.00	5	0.012	0.6	19.89	75
0.875	9	0.024	0.9	19.24	197
1.75	13	0.031	1.3	18.75	268
2.62	17	0.042	1.9	18.36	368
3.5	19	0.055	2.1	17.94	457

TS190							
BLEND	HC	CO	CO2	O2	NOX	SFC	BTHE
S1	1	0.01	0.7	19.74	102	4.21	0
	4	0.023	1.2	18.92	193	0.63	2.04
	5	0.027	1.95	18.16	248	0.41	13.58
	8	0.032	1.9	17.58	317	0.36	20.97
	13	0.041	2.3	16.8	452	0	24.02
S2	3	0.013	0.6	19.89	105	0.59	0
	5	0.023	1.3	19.17	198	0.41	14.41
	8	0.032	1.45	18.98	203	0.3	20.96
	11	0.041	1.9	17.76	265	0.32	28.3
	12	0.057	2.1	17.17	347	0	26.89
S3	5	0.02	0.8	19.31	87	15.69	0
	8	0.031	1.3	19.02	157	0.61	0.55
	10	0.041	1.7	18.78	212	0.42	14.13
	13	0.048	2.1	18.03	301	0.35	20.5
	16	0.053	2.2	17.58	399	0.29	24.27
S4	5	0.019	1.2	19.31	103	4.85	0
	7	0.024	1.3	18.78	189	0.62	1.17

	9	0.031	1.7	18.27	235	0.44	13.8
	11	0.038	2.1	18.56	312	0.36	19.7
	13	0.042	2.5	17.32	387	0.32	23.83

CHAPTER - 6

6.1 CONCLUSIONS

The Experimental analysis is study for alternative fuels feasibility. The source is using to develop the custard apple oil for future bio fuel. The biodiesel is analyzed the performance and characteristics of NOX, CO, HC, CO₂, O₂, BTH and SFC. Test has been conducted and the values are Tabled and chart has been drawn the values are come positive for the test results.

The results indicated the biodiesel is increased the brake thermal efficiency. Biodiesel sample are reduced the harmful gas effects in exhaust. Custard apple oil blends is equally blended. The blend sample S1. All samples are made for the blends for B20, B25 and B30 .The bi diesel is near to come the diesel values for the testing. It used for the alternative fuel for the transportation purpose.

Test results are come for NOX, CO, CO₂, HC has increased the O₂ has been decreased. All other parameter has shown the significant improvement for the diesel.

6.2 REFERENCES: -

- [1] Agarwal AK. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. *Prog Energy Combust Sci* 2007;33:233–71.
- [2] Nabi MN, Rahman MM, Akhter MS. Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions. *Appl ThermEng* 2009;29:2265–70.
- [3] Moser B. Comparative oxidative stability of fatty acid alkyl esters by accelerated methods. *J Amer Oil Chem Soc* 2009;86:699–706.
- [4] Demirbas A. Biodiesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other methods: a survey. *Energy Convers Manage* 2003;44:2093–109.
- [5] Escobar JC, Lora ES, Venturini OJ, Yáñez EE, Castillo EF, Almazan O. Biofuels: environment, technology and food security. *Renew Sust Energy Rev* 2009;13:1275–87.
- [6] Kivevele TT, Mbarawa MM. Comprehensive analysis of fuel properties of biodiesel from croton megalocarpus oil. *Energy Fuels* 2010;24:6151–5.
- [7] Ryu K. Effect of antioxidants on the oxidative stability and combustion characteristics of biodiesel fuels in an indirect-injection (IDI) diesel engine. *J Mech Sci Technol* 2009;23:3105–13.
- [8] Ryu K. The characteristics of performance and exhaust emissions of a diesel engine using a biodiesel with antioxidants. *Bioresour Technol* 2010;101:S78–82.

- [9] Kafuku G, Mbarawa M. Biodiesel production from croton megalocarpus oil and its process optimization. *Fuel* 2010;89:2556–60.
- [10] Aliyu B, Agnew B, Douglas S. Croton megalocarpus (musine) seeds as a potential source of bio-diesel. *Biomass Bioenergy* 2010;34:1495–9.
- [11] P. David, T.W. Patzek, Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower, *Natural Resource Research* 14 (1) (2005) 65e76.
- [12] M. Chudnoff, *Tropical Timbers of the World*. USDA Forest Services, 1984.
- [13] I.R. Dale, P.J. Greenway, *Kenya Trees and Shrubs*. Buchanan Estates, Nairobi, 1984.
- [14] H.J. Beentje, *Kenya Trees, Shrubs and Lianas*, 1994.
- [15] A.P. Roskilly, S.K. Nanda, Y.D. Wang, J. Chirkowski, The performance and the gaseous emissions of two small marine craft diesel engines fuelled with biodiesel, *Applied Thermal Engineering* 28 (2008) 872e880.
- [16] K. Pramanik, Properties and use of *Jatropha curcas* oil and diesel fuel blends in compression ignition engine, *Renewable Energy* 28 (2) (2003) 239e248.

[17] S. Puhan, N. Vedaraman, Mahua oil (*Madhuca indica* seed oil) methyl ester as biodiesel-preparation and emission characteristics, *Biomass and Bioenergy* 28 (1) (2005) 87e93.

[18] S. Puhan, N. Vedaraman, Performance and emission study of Mahua oil (*Madhuca indica* oil) ethyl ester in a 4-stroke natural aspirated direct injection diesel engine, *Renewable Energy* 30 (8) (2005) 1269e1278.

[19] H. Raheman, S.V. Ghadge, Performance of compression ignition engine with mahua (*Madhuca indica*) biodiesel, *Fuel* 86 (16) (2007) 2568e2573.

[20] M. Al-Widyan, G. Tashtoush, M. Abu-Qudais, Utilization of ethyl ester of waste vegetable oils as fuel in diesel engines, *Fuel Processing Technology* 76 (2) (2002) 91e103.

[21] A. Monyem, J.H. Van Gerpen, The effect of biodiesel oxidation on engine performance and emissions, *Biomass and Bioenergy* 20 (4) (2001) 317e325.

[22] N. Usta, E. Ozturk, B. Can, E.S. Conkur, S. Nas, A.H. Con, A.C. Can, M. Topcu, Combustion of biodiesel fuel produced from hazelnut soapstock/waste sunflower oil mixture in a diesel engine, *Energy Conversion and Management* 46 (2005) 741e755.

[23] M. Mittelbach, C. Remschmidt, *Biodiesel: the Comprehensive Handbook*. Martin Mittelbach, Austria, 2006.