

Experimental Study of Partly Premixed Charge with Rice bran Oil Methyl Ester and Diesel Blends in a IC Engine

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

VEDASHRITH SHIKILAMBATLA (37150204)

VADLAMURI VENKATESH VARMA (37150198)



**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

MARCH 2021



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in



DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Vedashrith shikilambatla (37150204) and Vadlamuri venkatesh varma (37150198) who carried out the project entitled '**Experimental Study of Partly Premixed Charge with Rice bran Oil Methyl Ester and Diesel Blends in a IC Engine**' under our supervision from December 2020 to march 2021.

Internal Guide

Dr. J. JAYAPRABAKAR, 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

We, Vedashrith shikilambatla (37150204) and Vadlamuri venkatesh varma (37150198) hereby declare that the Project Report entitled “**Experimental Study of Partly Premixed Charge with Rice bran Oil Methyl Ester Blends in a CI Engine**” done by us under the guidance of **Dr. J. JAYAPRABAKAR, M.E. Ph.D.**, at Sathyabama Institute of Science and Technology, Chennai is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 30.04.2020

PLACE: CHENNAI

1.

2.

SIGNATURE OF CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr.S.PRAKASH, M.E., Ph.D.**, Dean, School of Mechanical Engineering and **Dr.G.ARUNKUMAR, M.E., Ph.D.**, Head of the Department, Dept. of Mechanical Engineering for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **DR.J.JAYAPRABAKAR, M.E., Ph.D.**, for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering, who were helpful in many ways for the completion of the project.

ABSTRACT

In the present study, the influence of PCCI (premixed charge compression ignition) on performance, emission and combustion of a CI engine is experimentally studied. Fuel blend (20% biodiesel, 80% diesel and NaOH catalyst) is prepared. The prepared blend is tested for its properties according to American Society for Testing and Materials (ASTM) standards. The engine study was conducted by having 3 different kinds of injections of 10% PM, 20% PM and 30% PM (pre-mixed). The Brake Thermal Efficiency (BTE) is improved upon increasing the injection pressure. As a penalty NO_x emissions were increased since higher injection pressures promoted better combustion. But the Specific Fuel Consumption (SFC) is less at higher injection. The CO_2 Hydrocarbon emissions and smoke opacity values were increased at higher charge. The prepared blend can be used in a CI engine by pre-mixed ignition for improving the performance and combustion characteristics.

CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	iv
	LIST OF TABLES	viii
	LIST OF ABBREVIATIONS	ix
	LIST OF FIGURES	ix
1	INTRODUCTION	1
	1.1 INTRODUCTION	1
	1.2 BACKGROUND OF BIO-DIESEL	2
	1.3 GENERATIONS OF BIO-DIESEL	3
	1.3.1 The first generation of bio-fuels	3
	1.3.2 The second generation of bio-fuels	4
	1.3.3 The third generation of bio-fuels	4
	1.4 PCCI (Premixed charge compression ignition)	5
2	LITERATURE SURVEY	6
	2.1 INTRODUCTION	6
	2.2 PRE-MIXED CHARGE COMPRESSION IGNITION	7
	2.3 RICE BRAN OIL BLEND	8
	2.4 SUMMARY OF LITERATURE REVIEW	8
3	OBJECTIVE AND SCOPE	9
	3.1 OBJECTIVE	9
	3.2 SCOPE	9
4	MATERIALS AND METHODS	10

	4.1 MATERIALS	10
	4.2 PRODUCTION OF BIO-DIESEL FROM RICE BRAN OIL	10
	4.3 BLENDING	12
	4.4 PROPERTY TESTING	12
	4.4.1 Density measurement	12
	4.4.2 Viscosity management	13
	4.4.3 Calorific value management	14
	4.5 ENGINE SPECIFICATIONS	14
5	RESULTS AND DISCUSSION	15
	5.1 FUEL PROPERTY ANALYSIS	15
	5.2 PERFORMANCE GRAPHS	16
	5.2.1 Brake thermal efficiency	16
	5.2.2 Volumetric efficiency	17
	5.2.3 Exhaust gas temperature	18
	5.2.4 Specific fuel consumption	19
	5.3 EMISSION CHARACTERISTICS	20
	5.3.1 Carbon monoxide	20
	5.3.2 Carbon dioxide	21
	5.3.3 Nitrogen oxide (NO_x)	22
	5.3.4 hydrocarbon emission	23
	5.3.5 Smoke opacity	24
	5.4 COMBUSTION GRAPHS	25
	5.4.1 CRANK ANGLE VS CYLIDRICAL PRESSURE	25
	5.4.2 CRANK ANGLE VS NET HEAT RELEASE	28
6	SUMMARY AND CONCLUSIONS	31
7	REFERENCES	32

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
4.1	Production of biodiesel	11
4.2	Ultra sonic mixing machine	12
4.3	Density measurement	13
4.4.	Viscosity measurement	14
4.5	Calorific value measurement	15
5.1	Brake thermal efficiency	16
5.2.	Volumetric efficiency	17
5.3	Exhaust gas temperature	18
5.4	Specific fuel consumption	19
5.5	Carbon monoxide	20
5.6	Carbon dioxide	21
5.7	Nitrogen dioxide	22
5.8	Hydrocarbon emission	23
5.9	Smoke opacity	24
5.10	Cylindrical pressure at 0% load	25
5.11	Cylindircal pressure at 25% load	26
5.12	Cylindircal pressure at 50% load	26
5.13	Cylindircal pressure at 75% load	27
5.14	Cylindrical pressure at 100% load	27
5.15	Net heat release at 0% load	28
5.16	Net heat release at 25% load	29
5.17	Net heat release at 50% load	29
5.18	Net heat release at 75% load	30
5.19	Net heat release at 100% load	30

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1.1	Generations of bio fuels	3
4.1	Transesterification properties	11
4.2	Engine specifications	14
5.1	RB20 Fuel properties	16

LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
B20	-	20% biodiesel and 80% diesel
PCCI	-	Premixed charge compression ignition
BSFC	-	Brake Specific Fuel Consumption
SFC	-	Specific fuel consumption
BTE	-	Brake thermal efficiency
EGT	-	Exhaust gas temperature
CP	-	Cylindrical pressure
HR	-	Heat release
PM	-	Premixed
RB20	-	Rice bran biodiesel

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO BIO-DIESEL

The Transportation Committee of the Montana House of Representatives heard testimony on House Bill 502, which proposed that all diesel fuel sold for use in internal combustion engines contain at least 2 percent biodiesel fuel by volume. The bill was discussed but tabled by the committee because of “unanswered questions surrounding this relatively new technology.” Specific concerns included:

- “the effects of biodiesel blends on engine performance – specifically fuel economy, torque, and power – as compared to diesel;
- cold weather product storage and potential for gelling;
- sulfur, carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxide (NO_x), and other emissions; and
- Potential for engine damage.” (1)

The Montana Department of Transportation (MDT) was asked by the House Transportation Committee to initiate a research project focusing on the viability of using biodiesel as an alternative fuel in MDT’s vehicle fleet. To undertake this study, MDT is seeking to implement this project in two phases: first, a review of relevant literature regarding the performance of biodiesel in motor vehicles; and second, a test application using a B20 blend (20 percent oilseed based biodiesel, 80 percent conventional diesel) in three MDT vehicles housed in Missoula and three housed in Havre.

It examines the body of literature that currently exists regarding laboratory and field experience with the use of biodiesel fuels, with an emphasis on oilseed-based biodiesel. The information gathered in this review should provide MDT and the State Legislature with better information to help them make decisions regarding the future usage of biodiesel fuels in the state.

1.2 BACKGROUND ON BIODIESEL

Before proceeding to answer the research questions, it is important to establish some background about what biodiesel is, what it is made of, what its principal properties are, and the extent of its current usage in the state. This chapter will provide that foundation.

Definition

In 1895, Rudolf Diesel developed a new engine with the intention that it could use a variety of fuels, including vegetable oil. When he showcased it to the public at the 1900 Paris World's fair, he had the engine run on peanut oil. As the diesel engine became more widely adopted in subsequent years, however, petroleum-based diesel fuel proved to be less expensive and became the fuel of choice (2).

Biodiesel's definition has been a work in progress. Since the early 1900s, biodiesel has been defined as an alternative form of diesel fuel made from vegetable oils or animal fats and alcohol (3). The definition of biodiesel was neither legally definable nor defensible in the United States for about a century. This changed when biodiesel was registered with the U.S. Environmental Protection Agency (EPA) as a fuel and a fuel additive under section 211(b) of the Clean Air Act (4). With help from the American Society of Testing & Materials (ASTM), subsequent legislation such as the Energy Policy Act (EPAct) helped further define biodiesel. In December 2001, the ASTM issued defined physical/chemical constraints for biodiesel and subsequently for mixtures of biodiesel with diesel fuel (5). An important distinction needs to be made between biodiesel and biodiesel blends. Biodiesel is commonly mixed with diesel No. 2 to form a biodiesel blend. As stated above, a mixture of biodiesel and diesel is not biodiesel, but is referred to as a biodiesel blend. Pure biodiesel, also known as neat biodiesel, is commonly noted as B100, indicating that the fuel has 100 percent biodiesel (noted by the 100) and 0 percent diesel. The most common biodiesel blend is B20, which contains 20 percent biodiesel and 80 percent diesel.

1.3 GENERATIONS OF BIODIESEL

When this biodiesel came into light many started producing it from food crops. Due to which there was instability in food supply and sudden hike in cost of food crops. So with this the generations of biodiesel have started.

There are four generations of biodiesel. They are:

- i. The first generation
- ii. The second generation
- iii. The third generation

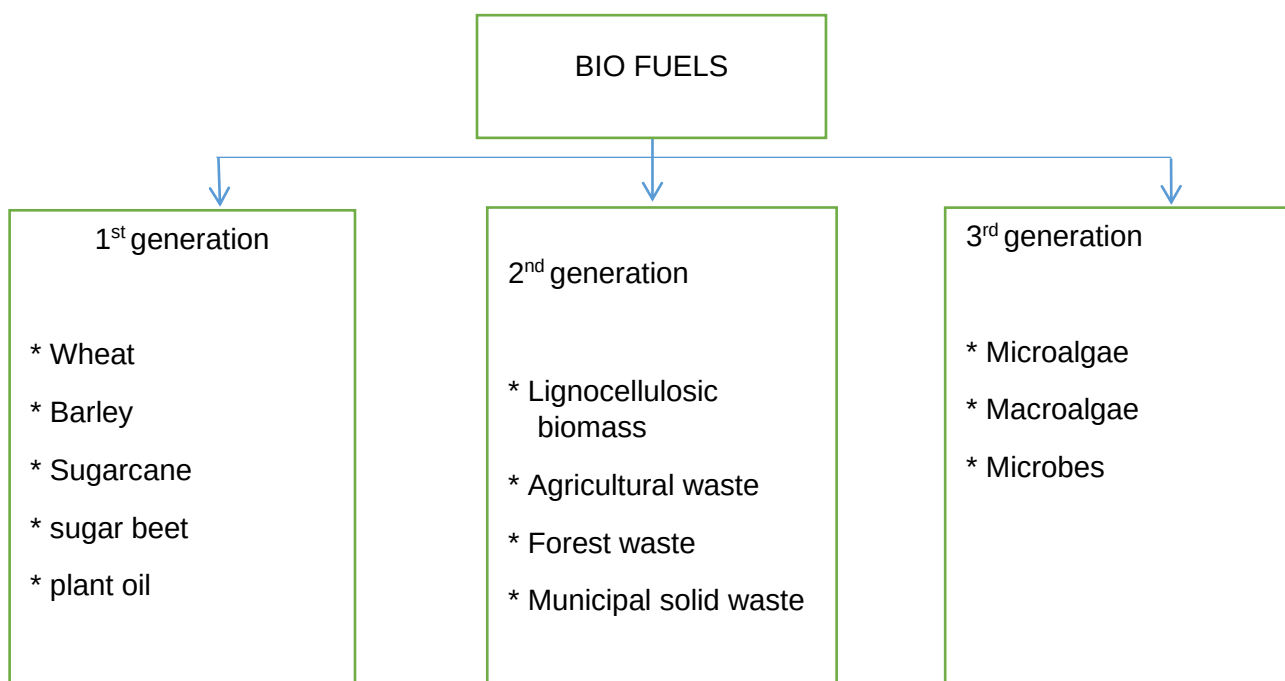


Table no.1.1 Generations of Biodiesel

1.3.1 THE FIRST GENERATION OF BIODUELS

These first generation of biofuels are produced from agricultural crops, which are a vital food source for humans. In this generation the biodiesel is made from corn starch, sugar from potatoes and vegetable oil obtained from the crops which humans consume on a daily basis. Scientist feared that it may cause an instability in the environment because of the growing demand for the oils. This would also

create competition within the farmers. Thus leading to usage of excess fertilizers and pesticides to increase the crop yield. This would change the chemical properties of the biodiesel to a certain extent. So this type of production of biodiesel was not entertained.

1.3.2 THE SECOND GENERATION OF BIOFUELS

The second generation has come into existence because of the fear of the scientists that the first generation may cause imbalance and shortage of food supply. This led to change of feed stock to non-edible sources such as harvest wastes, municipal solid waste, foods that already fulfilled their purpose(Used cooking oil). These second generation biofuels are made from cellulosic biomass or waste plant materials. This helps to reduce the burden on the edible oil for preparation of biodiesel. So here no arable land is used solely for production of biodiesel, Biodiesel production from waste animal fat and improvement of its characteristics by synthesized nickel and magnesium additive. Energy Convers Management 2009; 50(3): 498-502.its waste product is used for production of biodiesel. Non-edible food second generation feedstock include used cooking oil, jatropha oil, grasses and other seed oils. To convert cellulose biomass to biodiesel a series of pre-treatment is required.

1.3.3 THE THIRD GENERATION OF BIOFUELS

Scientists found that algae is rich in oil content and it is unwanted plant. It grows in waste-water and absorbs oxygen from the water bodies. It also does not require any arable land for growing. So this feature has made algae very efficient to grow. This algae can be grown in pond and waste water treatment plants. It is not used commercially because its extraction is costly and pretreatment is required. Eventually after extraction is made easier it will be commercially used on a large scale.

1.4 PCCI (PREMIXED CHARGE COMPRESSION IGNITION)

Premixed charge is prepared initially in inlet manifold and the remaining quantity of fuel injected into the cylinder by conventional mode. It is actually injected into the manifold by solenoid operating injector controlled by ECU (electronic control unit).

It is a advanced low temperature combustion in which the injected fuel is premixed with the inducted charge, subsequently combusted via compression induced auto ignition. It is a strategy in which early injection is used causing a burning process in which the fuel burns in premixed condition. PCCI engine gives thermal efficiency close to CI engine and resolves the problem of high NO_x and PM simultaneously. Premixing of air and fuel preparation is the challenging part to achieve PCCI combustion.

The PCCI injection works on solenoid operated injector which is controlled by ECU and it is connected to the dynamo. The injection of fuel depends on the RPM and the load given. When the load and RPM increases, the injection of the fuel decreases. The premixed charge of 10%, 20% and 30% is injected into the combustion chamber directly for quick combustion process.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

A substantial amount research has been undergone into the production of various biodiesels, high performance fuel properties and their performance in CI engine. Though many researchers have investigated various biodiesel blends with alcohols (higher and lower) and Hydrocarbon based diesel, very few literature reviews are available on quaternary blends as a substituent for compression ignition engine. A decent amount of literatures were studied and as an outcome this methodology was designed and experiments were performed. Numerous amount of research papers have been published in reputed National and International journals, among which performance, combustion and emission characteristics of varying injection pressure for diesel CI engine has been reviewed for this present work. Many of the journal mainly concentrated on biodiesel and its blending with diesel and alcohol in different proportions to optimize the blend, tested in unmodified engine. Increased injection pressures lead to smooth functioning of the engine. Also it lead to atomisation of fuel similarly usage of premixed charge for the biodiesel blend lead to emission characteristics similar to that of diesel. S. Sendilvelan & K. Bhaskar reported that biodiesel showed similar characteristics similar to diesel and also found that base catalyst yields more than acid catalyst. It is also observed that the performance of engine was lowered on using vegetable oil, due to high viscosity of oil it lead to injector choking and contamination of lubricating oil. Similar test when conducted using refined oil blends showed improvement in the performance.

2.2 Premixed charge compression ignition

Ayush Jain, Akhilendra pratap singh, Avinash kumar agarwal investigated on combustion stability and emissions of a mineral diesel fueled PCCI, In this the combustion could be achieved in both the ways CI and PCCI, Here BTE has decreased on increase in pressure and BTE was less in low pressure. SFC has increased on increase in load. NO_x emissions were less in every pressure but CO and HC emissions were high.

combustion chamber.

Girish E. Bhiogade, Neeraj sunheriya and J.G Suryawanshi investigated on PCCI engines, they compared PCCI with CI engines as PCCI is the new combustion concept. They describes about the early injection which causes the burning process in which fuel burns in premixed condition, emissions are the unsolved issue in the engines where PCCI is the promising solution that combines the advantages of SI and CI modes of combustion. Their experiment consists of 4 stroke cylinder engine and water cooled CI engine. They found that the reduction in BTE for PCCI and HC and CO emissions were higher in PCCI mode than in CI mode, there was a reduction NO_x emission by 41.66% for PCCI.

S. Sendilvelan & K. Bhaskar they investigated and found that the SFC and BTE are highest at 25% PCCI and bio-diesel conventional, it is getting decreased on increase in load. SEC is higher and hence brake thermal efficiency is lower for the methyl ester and diesel PCCI mode at all power outputs compared to diesel. At full load the SEC of various modes tested varies from 12432 kJ/kWh to 14875 kJ/kWh. Higher Kinematic viscosities of biodiesel blends compared to that of diesel results in poor atomization, vaporization and dispersion of fuel in the Xiaobei Cheng, Shuai li, Jin yang, Bei Liu investigated regarding N-butanol diesel blends with premixed combustion fuel, In this experiment they used turbocharged 4-cylinder light duty diesel engine where premixed combustion which is an early injection into the combustion chamber. They proved that premixed combustion reduces the NO_x levels for N-butanol.

2.3 Rice brand oil blend

B.K Venkanna, C. Venkataramana reddy, Swati B Wadawadagi investigated on direct fuel injection diesel engine running on rice bran oil. In this they found out the difference between B100 and ND at different loads. BSFC for B100 blend is high at 25% load following by 50% load. Emissions of HC is getting increased in increase in load to 100% not only HC but also NO_x, CO .This shows the efficiency of B100 blend.

R. Vidya Sagar Raju, V. Nageswara Reddy, G. Narasa Raju, Dr. G. Sreenivas Rao has investigated on effect of super charging and rice bran oil as an additive in Diesel-Ethanol Blends for Diesel engines, they proved that the super charging improves engine performance. The BSFC of biodiesel and all other fuel blends was higher than that of diesel fuel. Exhaust temperature of that blend was slightly lower than that of diesel fuel throughout the range of load

S Sinha, Avinash Kumar Agarwal investigated on combustion characteristics of a biodiesel (rice bran oil methyl ester) fuelled direct injection. In this peak pressure increase in increase in the load, the peak pressure is high for bio blends at lower loads as it shows in their paper. According to the paper B20 and B10 have low net heat release which depends on the load

2.4 SUMMARY OF LITERATURE REVIEW

A set of literature reviews were referred and a valid course of action was determined and used in the current research work. The arrived conclusions are:

- Bio-diesel from rice bran oil efficient in medium loads compared to low or high loads, so it is a good alternative fuel for CI engines.
- As we know that edible oils are suitable for the performance

CHAPTER 3

AIM AND SCOPE

3.1 AIM

- Investigation is led on B20 biodiesel because of its good balance of cost, less emissions, cold-weather performance and equipment compatibility.
- To prepare a blend of rice-bran oil and diesel by the process of transesterification with 20% biodiesel and 80% diesel.
- To perform Premixed charge compression ignition (PCCI) test in CI engine by 10%, 20% and 30% premixed charge injection.
- To suggest a suitable blending ratio according to the fuel consumption.
- Optimizing the result and analysis of the test

3.2 SCOPE

Biodiesel is considered to be an alternate fuel, plays a major role in the reduction of pollutant particles suspended into atmosphere on emission. It also solves fossil fuels demand by providing a sustainable solution. This research work provides a solution for using high viscous blends in unmodified diesel engines. Also to provide premixed charge compression ignition (PCCI) for the most efficient way of functioning of the diesel engine.

CHAPTER 4

MATERIALS AND METHODS

The process is classified into three phases:

- Preparation of biodiesel
- A 5L B20 oil blend blend was prepared using 80% of diesel(4L) and 20% of biodiesel(1L of rice bran oil) also known as high performance fuel blend
- Engine testing and analysis

4.1 MATERIALS

- Methanol
- Diesel
- Rice bran oil
- NaOH (catalyst)

4.2 PRODUCTION OF BIO-DIESEL FROM RICE BRAN OIL

Initially for preparation of Bio Diesel, Rice bran oil is purchased from outside. (6:1 molar ratio (Methanol : WCO) of Methanol and base catalyst NaOH pellets (0.5 wt% of WCO) were used for the Transesterification process. The figure shows the experimental setup of preparation of biodiesel. A three necked round bottom glass flask having a capacity of 5 litres was set up as a batch reactor to produce bio diesel. The reaction took place for one and half hour. This reactor was equipped with a magnetic stirrer with a speed indicator, a condenser, and a thermometer pocket with a thermocouple. The sample is maintained at constant reaction temperature within $\pm 0.1^{\circ}$. Recommended amount of sample is preheated in the batch reactor. The Methanol and base catalyst were mixed together in a conical flask. The solution in the Conical flask after achieving the required

temperature is then transferred into the batch reactor. After reaction is complete the sample solution is poured into a separating funnel, Here the glycerol is separated from the required Biodiesel. Residual Methanol is removed from the sample by a rotatory

TRANSESTERIFICATION PROCESS



Fig 4.1 transesterification of bio-diesel

S.No	Parameters	Results
1	Free fatty acid	0.50%
2	Catalyst (NaOH) quantity	5 grams
3	Oil to methanol molar ratio	1:6
4	Temperature	60 °C
5	Reaction time	90 minutes
6	Yield	93.4 %

Table no. 4.1 Transesterification properties

4.3 BLENDING

- Bio diesel used is B20 which is 20% bio diesel and 80% diesel.
- Quantity is 5L in which 4L is diesel and 1L is rice bran oil
- The prepared blend is emulsified using power ultra sound machine which creates fine size emulsions with droplets in the micron and Nano ranges. This helps to mix the prepared blend very efficiently leading to constant viscosity throughout the fuel. This helps in better atomization and burning of fuel.



Fig : 4.2 ultrasonic mixing machine

4.4 PROPERTY TESTING

The main aim of property testing is to compare the physical and chemical properties of the fuel blend with the standard values. The prepared fuel blend is tested for their physical and chemical properties using various scientific instruments, and the results are obtained.

4.4.1 Density measurement

Hydrometer, It is a device which is used to find the specific gravity. It has an accuracy of 0.01. The density of biodiesel blend is measured using hydrometer. Hydrometer with a suitable specific gravity is selected and 250ml of biodiesel

blend is poured into the beaker. The hydrometer was immersed into the beaker and stabilization took place. After immersion the specific gravity value was displayed on the hydrometer



Fig 4.3. density measurement

4.4.2 Viscosity measurement

The viscosity is measured using a Canon-Fenske Viscometer. The viscosity tube was cleaned with acetone solution and dried. 50ml of biodiesel was poured into the viscosity tube. Suction force was applied to pull the diesel to the upper mark of the viscometer. Viscometer was placed in constant temperature bath with the help of a holder and set the bath temperature at 40°C for a duration of Half hour in order to bring the biodiesel sample to the bath temperature. Once the biodiesel has reached the upper mark the suction force was removed and time was recorded for the biodiesel to reach lower mark from the upper mark.



Fig 4.4 viscosity measurement

4.4.3 Calorific value measurement

The calorific value is determined using a Bomb calorimeter, The calorimeter consist of bomb, firing unit, offset stirrer, gas release valve, water jacket, timer, pressure gauge, crucible, ignition wire, thermometer and calorimeter vessel. Calorific value is determined by calculating the amount of heat generator when 10ml of biodiesel blend was burnt in a closed chamber.



Fig 4.5. calorific value measurement

4.5 ENGINE SPECIFICATIONS

The specifications of the engine are used to carry out the tests are as follows:

Rated power	5.2 kW
Rated speed	1500rpm
Bore diameter (D)	87.5mm
Stroke (L)	110mm
Compression ratio	17:5:1
C.V of Fuel for diesel	42,000kJ/kg
Density of diesel	830 kg/m ³

CHAPTER 5

RESULTS AND DISCUSSION

5.1 FUEL PROPERTY ANALYSIS

The production of biodiesel is optimized and evaluated by performing transesterification process. The transesterification process took place at 60-65°C for about 90 minutes. Excess methanol at a ratio of 6:1 methanol to oil was used in order to achieve higher yields of biodiesel. KOH was used as a catalyst with to achieve maximum yield of 96%. It is also observed that properties of high performance fuel sample given in table 5.1 were within the range of ASTM standards of biodiesel. If we consider different property tests of high performance fuel, Biodiesel and Diesel it is observed that copper corrosion test gave the same results for all types of fuels mentioned. In case of Cloud point it is at -1 °C for conventional diesel, biodiesel and High performance fuel blend. During combustion process the calorific value places a very vital role, higher calorific values are recommended. Referring to the figure 5.1 it is observed that there is very less variation in the calorific values (i.e. Diesel-9235.23 Cal/g, Biodiesel-7445.65 Cal/g and high performance fuel blend-8818.116 Cal/g). Similarly, all the properties were in par with the Conventional diesel. High performance fuel and biodiesel are exhibiting very high pour point temperature, that means these fuels can be used in very low temperature up to -8 °C. This is a very desirable quality of the fuel because in many countries like U.S.A, Russia, China, and Canada have temperature below 0 °C.

S.NO	PARAMETERS	RESULT
1.	Acid value	0.42 mg NaOH/g of oil
2.	Density	0.8524 g/cc
3.	Kinematic Viscosity @ 40° C	1.69 cSt
4.	Copper Strip Corrosion @ 60° C for 3hrs	1 a
5.	Flash point by PMCC method	153° C
6.	Fire point by PMCC method	161° C
7.	Cloud point	20° C
8.	Pour point	13° C
9.	Moisture content	0.06%
10.	Calorific value	9842.6 Cal/g

Table no. 5.1 RB20 Fuel properties

5.2. PERFORMANCE GRAPHS

5.2.1 Brake thermal efficiency

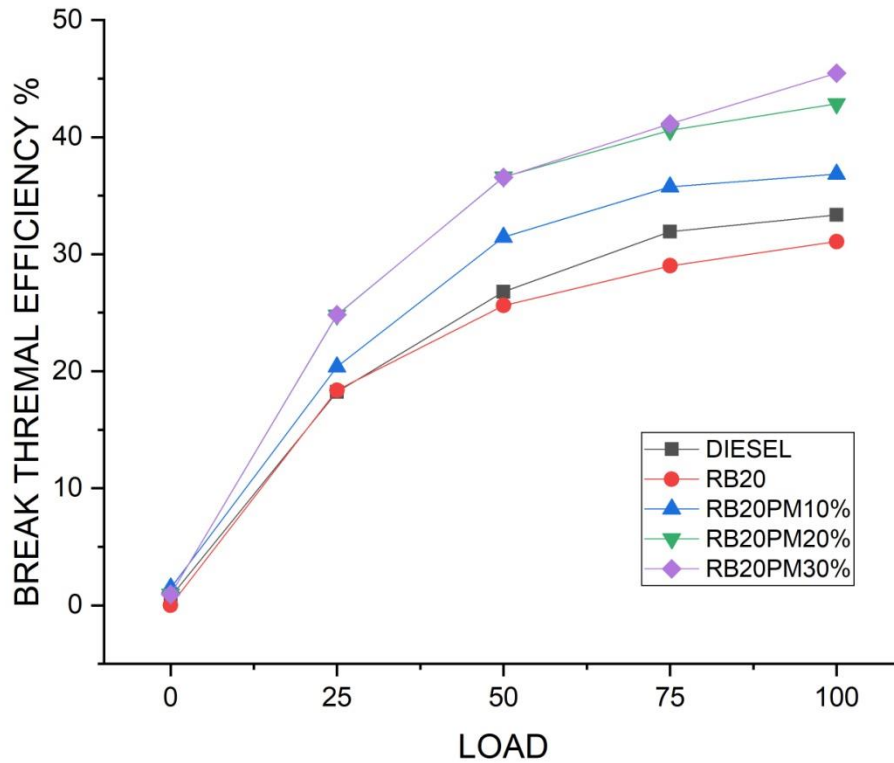


Fig 5.1 break thermal efficiency

The ratio of the output power to the input power which is equivalent to the energy consumed to produce that power is known as Brake thermal efficiency. The fuel properties like heating value and density will largely affect the break thermal efficiency. This gives the information of engine performance which converts the heat energy into the mechanical energy.

Brake thermal efficiency will increase with an increase in the load in all cases of blended fuels. As the load increases there will be a reduction in the heat loss. This brake thermal efficiency of the engine will increase as we keep on increasing the ester content in preparing blend. It can be inferred from the graph that the RB20-30% has the highest BTE followed by RB20-20% and RB20-10%, diesel and RB20-normal. It clearly shows that the 30% premixed charge has the highest BTE throughout the injection.

5.2.2 Volumetric efficiency

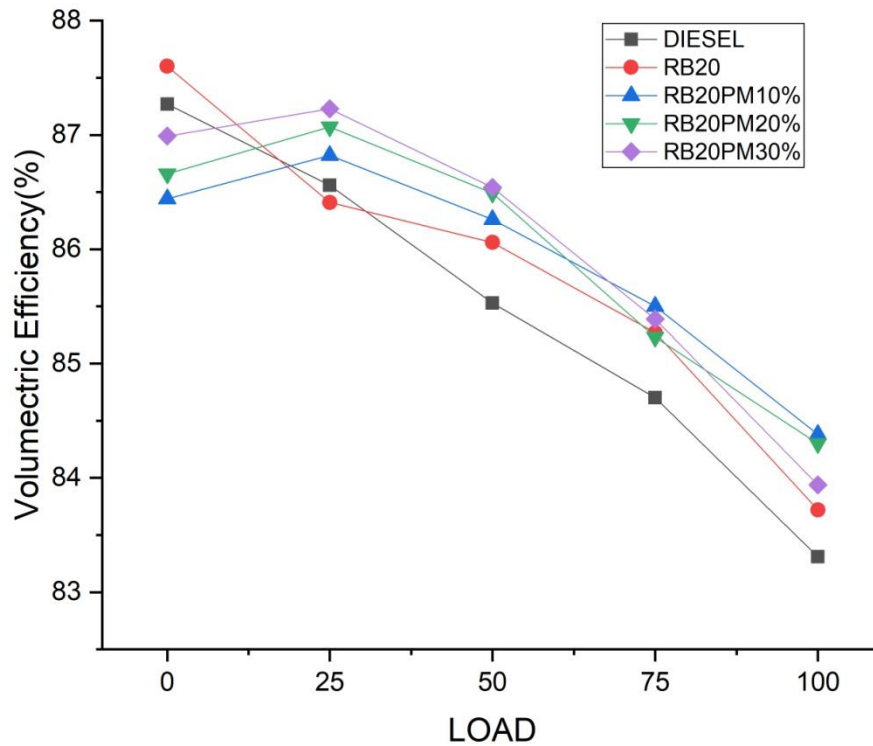


Fig 5.2 volumetric efficiency

Volumetric efficiency is the ratio of volume of air sucked by the engine to volume swept by the piston. Piston moves towards bottom dead center in expansion stroke but the volume it sucks from outside is not the same it has swept while expanding.

As shown in the graph RB20 has the highest volumetric efficiency but by increasing the load we can see that volumetric efficiency is decreasing at different conditions. RB20-PM10% has the highest volumetric efficiency at the maximum load.

5.2.3 Exhaust gas temperature

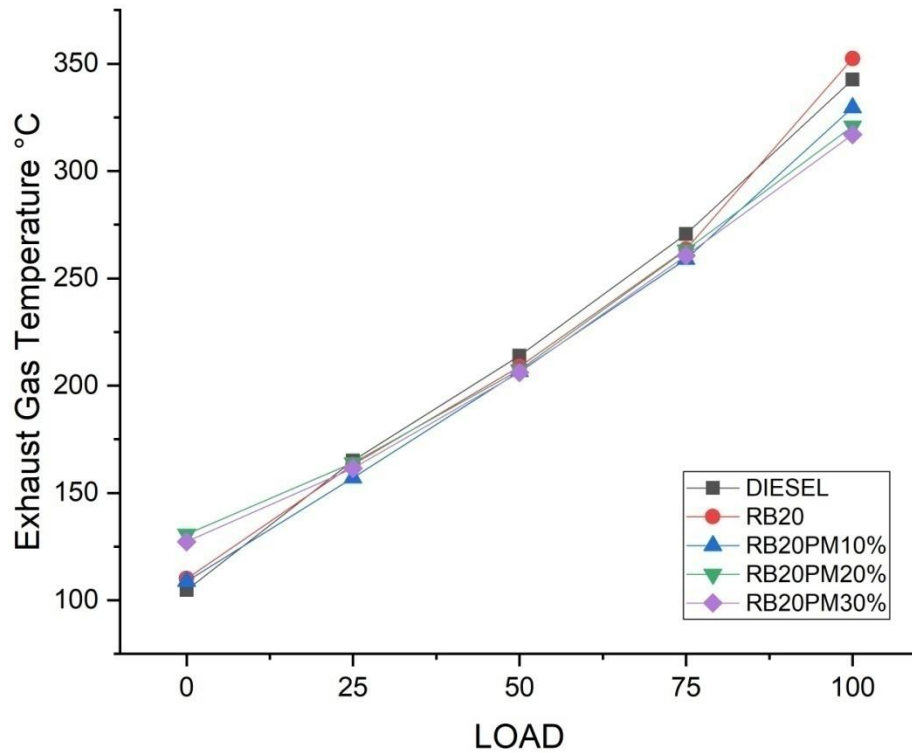


Fig 5.3 exhaust gas temperature.

Exhaust Gas Temperature is a measurement of exhaust gas temperature. It measures gas at the manifold of the engine. For proper functioning of catalytic converter in an internal combustion engine, exhaust gas temperature (EGT) is needed. As shown in the graph exhaust gas temperature is getting increased by increase in loads, at the maximum load RB20 has the highest exhaust gas temperature compared to other fuels. At maximum load RB20-PM30% has the lowest exhaust temperature.

5.2.4 Specific fuel consumption

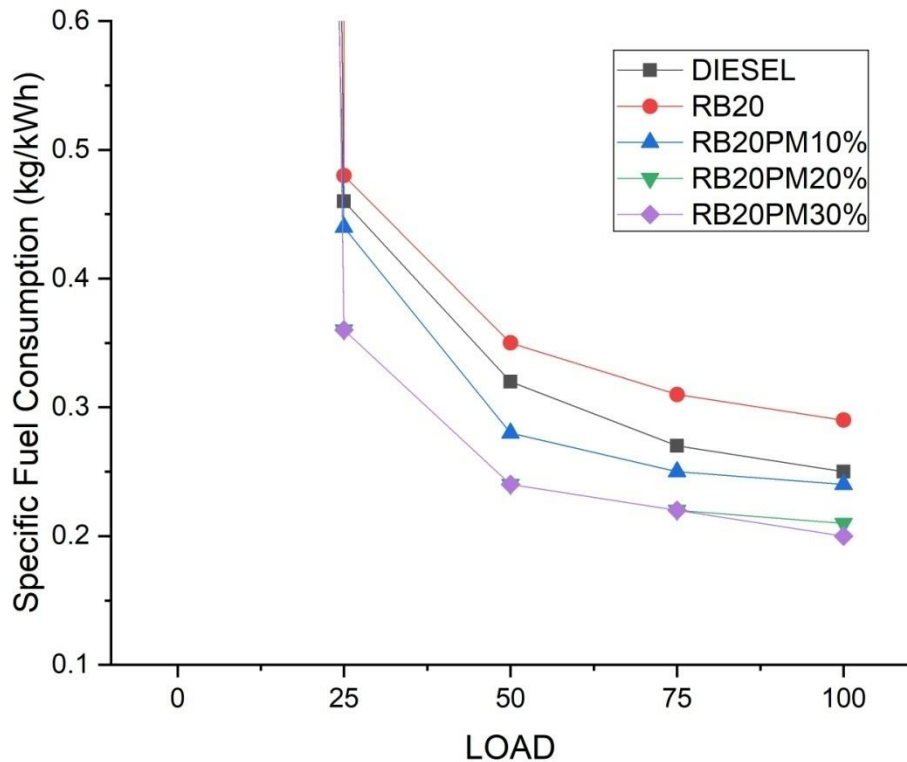


Fig 5.4 specific fuel consumption.

It is amount of fuel consumed by a vehicle for each unit of power output. specific fuel consumption of an engine is the rate of fuel burnt to produce a unit of thrust. It is used to compare the efficiency of IC engines with shaft output.

The graph shows the specific fuel consumption at different loads, As the load increases the specific fuel consumption decreases. In this RB20-PM30% has the lowest specific fuel consumption compared to diesel and RB20 and others.

5.3 EMISSION CHARACTERISTICS

5.3.1 Carbon monoxide

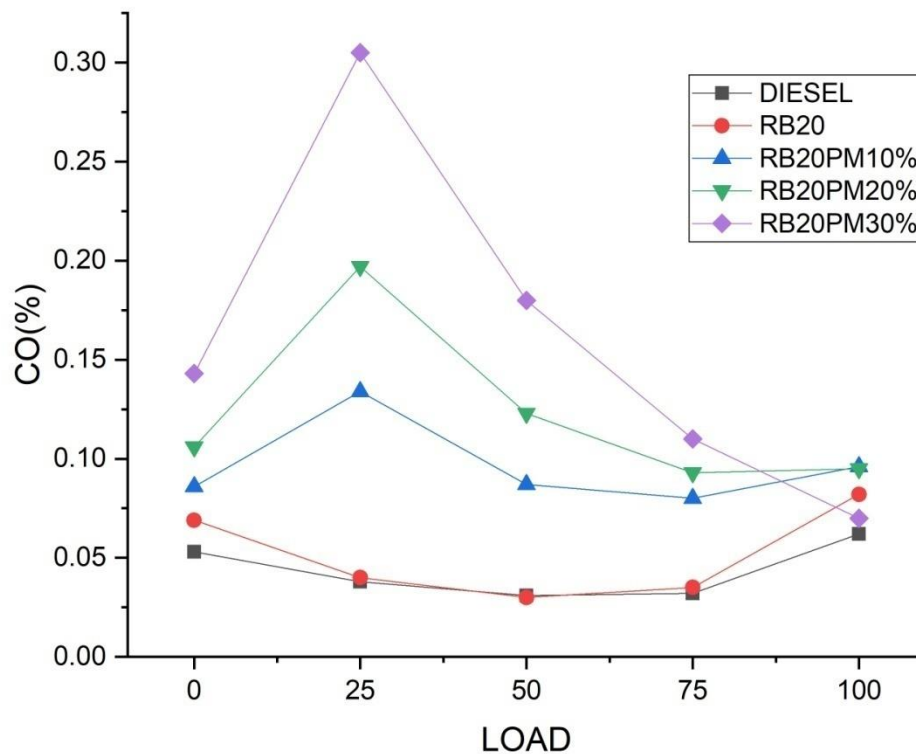


Fig 5.5 carbon monoxide

CO is transparent, tasteless gas. It is very harmful when it is inhaled in large amount. It is very harmful for every living being. Its is released when something is burned outside. It mainly caused due to vehicle emission, burning of fossil fuels.

In this graph the lowest CO emission is for diesel and RB20 is approximately same. The highest CO emission is RB30-PM30% at certain load, but after the maximum load it is as low as diesel .

5.3.2 Carbon dioxide

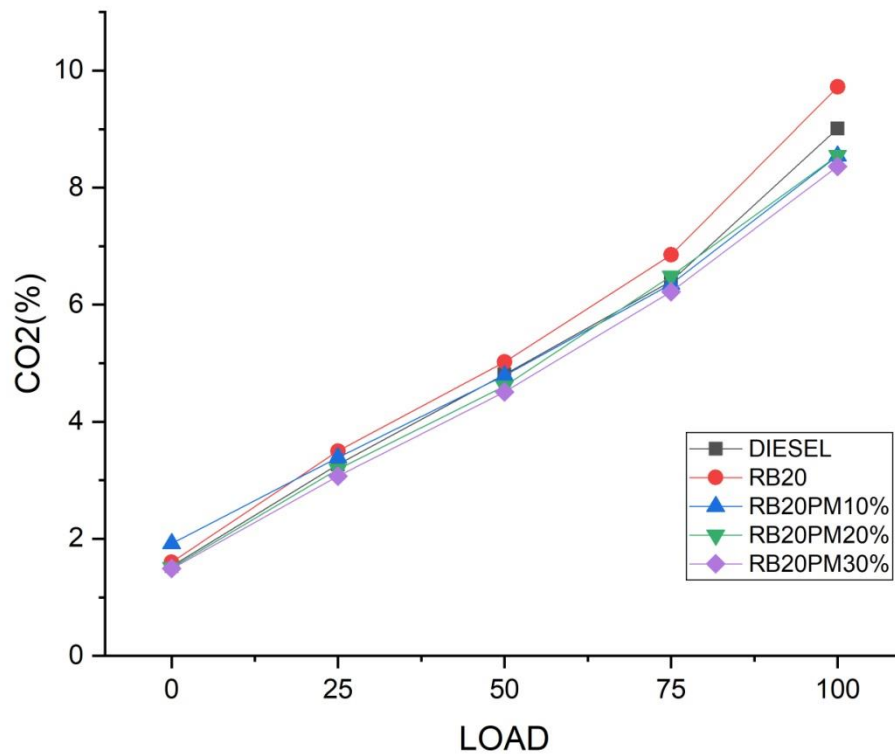


Fig 5.6 carbon dioxide

The emission of CO₂ shows the complete combustion of the air-fuel mixture. It shows that there was an adequate supply for oxygen for the fuel which was sprayed into the chamber. CO₂ is one of the basic greenhouse gases which gets released into the atmosphere along with the other exhaust gases. CO₂ does not harm the atmosphere much since it is the gas which is taken in by plants for its survival. Carbon dioxide emissions are the primary driver of global climate change. It's widely recognised that to avoid the worst impacts of climate change, the world needs to urgently reduce emissions. In this graph RB20-PM30% has the lowest emission in the highest load and in the lowest load, RB20 has the highest emission at highest load, but most fuels are almost same at the end.

5.3.3 Nitrogen oxide (NO_x)

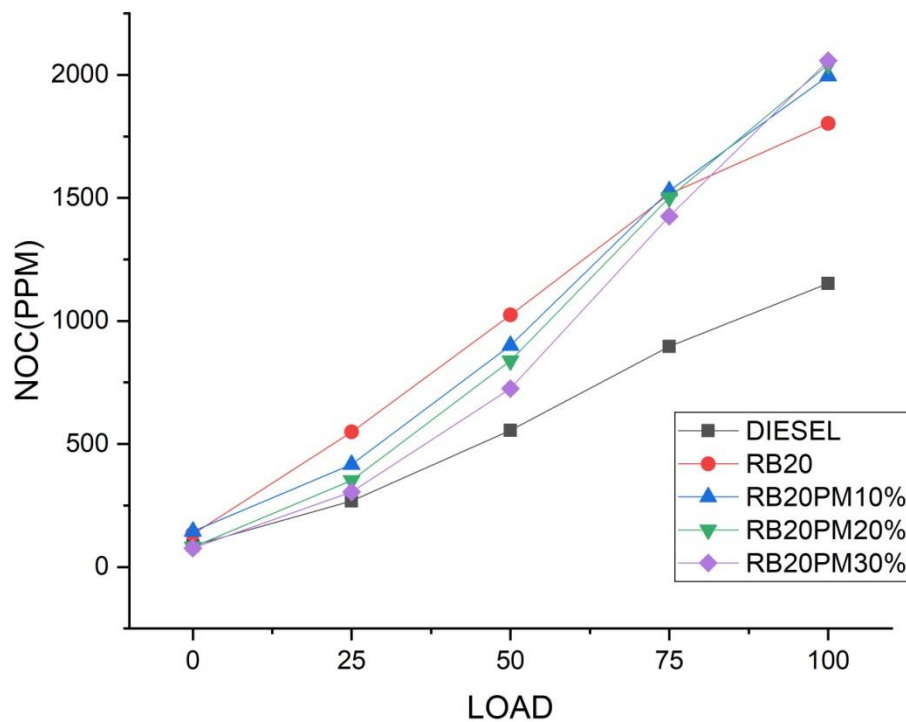


Fig 5.7 nitrogen oxide

Nitrogen Oxides are very poisonous, highly reactive gases. These gases evolved when fuel is burned at high temperatures. NO_x pollution is emitted by automobiles, trucks and various non-road vehicles (example construction equipment, boat). It looks like a brownish gas.

In this graph Diesel has the lowest emission of NO_x at the lowest load and highest load, Highest emission is for RB20-PM30% load compared to other loads.

5.3.4 Hydrocarbon emission

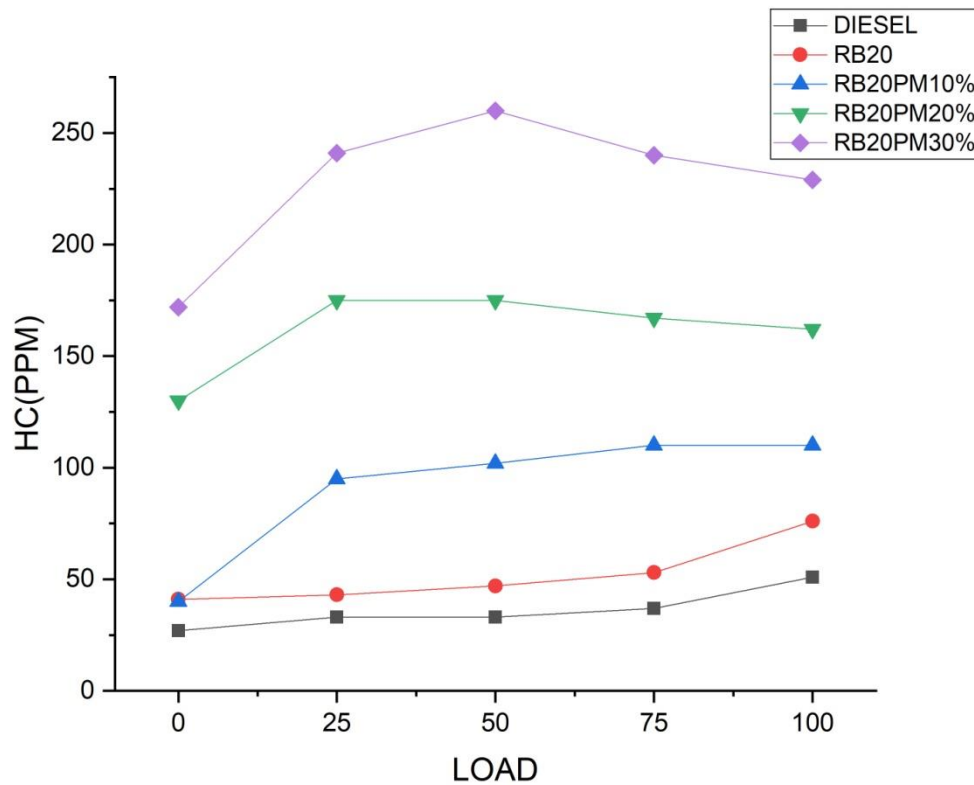


Fig 5.8 hydrocarbon emission

It is mainly due to incomplete combustion of fuel in the combustion chamber. It is simply a unburned fuel being pumped raw into the exhaust system. Mostly may cause ignition problem or internal engine failure and that reduces compression. Because of poor ignition of fuel will release large of HC to atmosphere.

As shown in the graph RB20-PM30% has the highest HC emission value at the maximum load. DIESEL has the lowest emission value at both maximum & minimum loads.

5.3.5 Smoke opacity

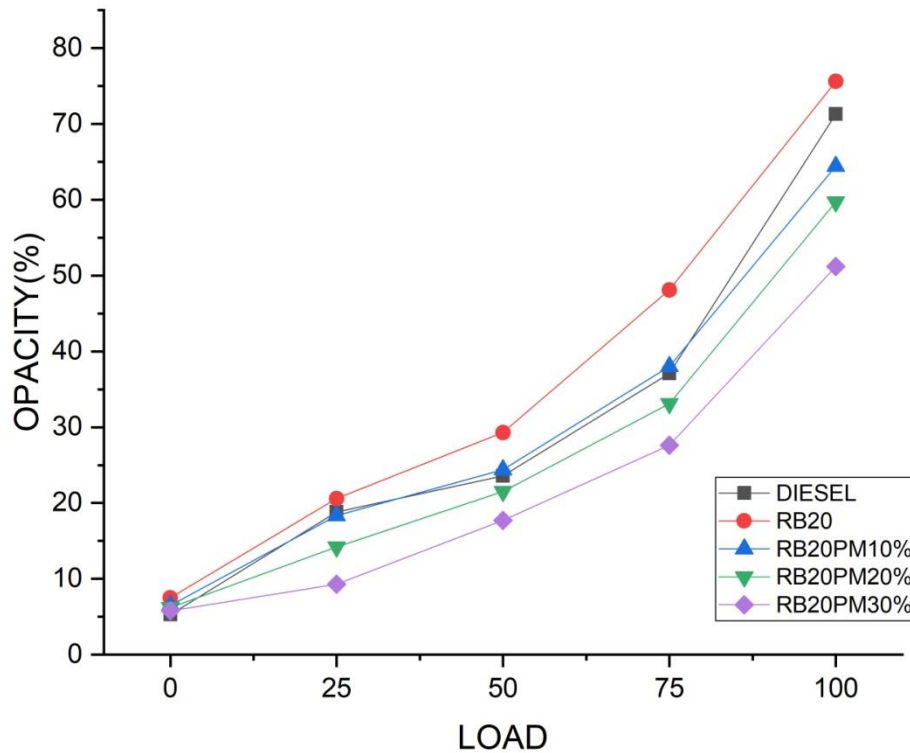


Fig 5.9 smoke opacity

It is a type of emission particles which produce due to the deposition of fuel on the cylinder wall. Smoke opacity is the degree to which smoke block lights and helps in the measuring of the smoke which comes out from the IC engine due to the fuel left on the cylinder walls. It has some particulate matters such as CO, CO₂, NO_x, HC. It is harmful to health. As shown in the graph, RB20 has the highest opacity at both maximum & minimum loads, RB20-PM30% has the lowest opacity at the maximum load.

5.4 COMBUSTION GRAPHS

5.4.1 Crank angle vs cylindrical pressure

The below graph represents crank angle and cylindrical pressure, we can see that the cylindrical pressure is more in diesel and RB20-PM 30% has lowest CP in lower loads. When the crank angle is increasing, the CP for RB20-30% is getting increased. At 0% load DIESEL has the highest CP and RB20-PM30% has lowest CP. At 25% load RB20-PM30% has lowest CP and DIESEL has highest CP. Load at 50% load DIESEL has highest CP followed by RB20 and RB20-PM30% has lowest CP. At 75% load RB20-PM30% has highest CP followed by RB20-PM20% and lowest is RB20. At the highest load (100% load) RB20-PM30% has highest CP and DIESEL has lowest CP. So we can see that increase in crank angle is inversely proportional to cylindrical pressure.

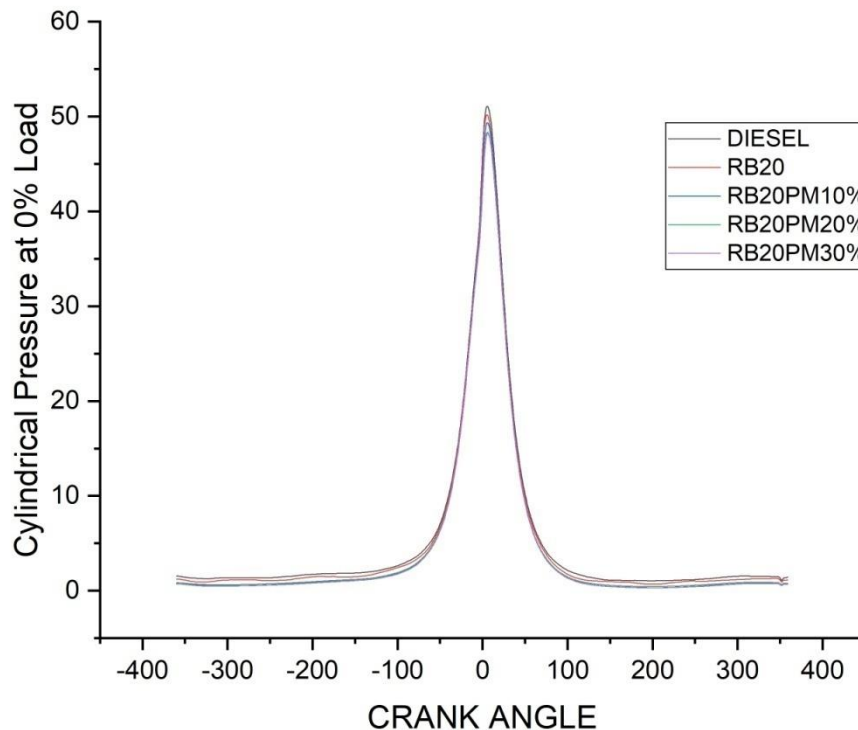


Fig 5.10 cylindrical pressure at 0% load

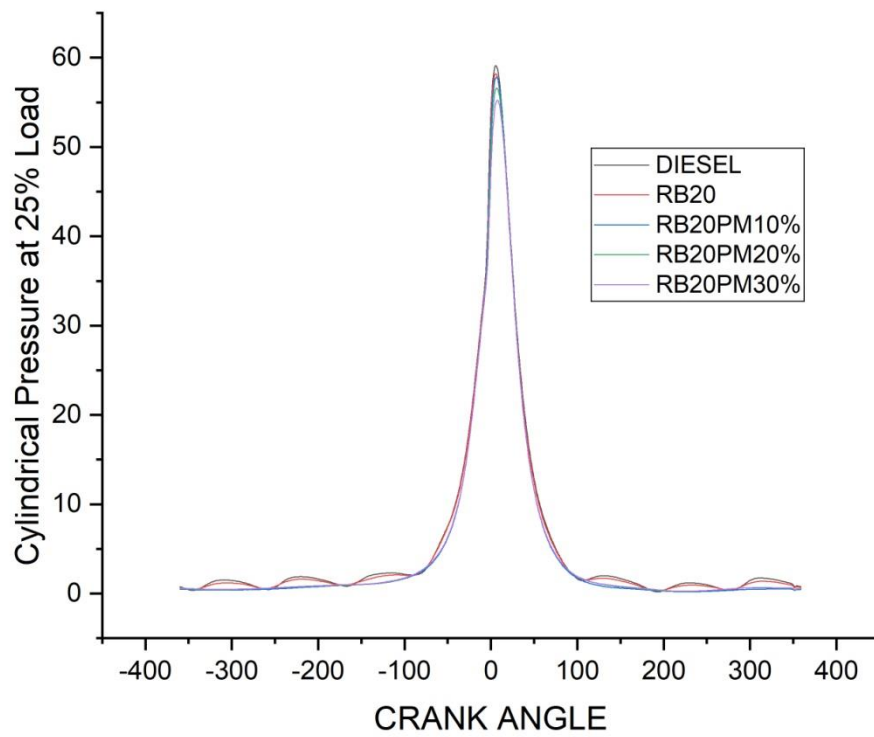


fig 5.11 cylindrical pressure at 25% load

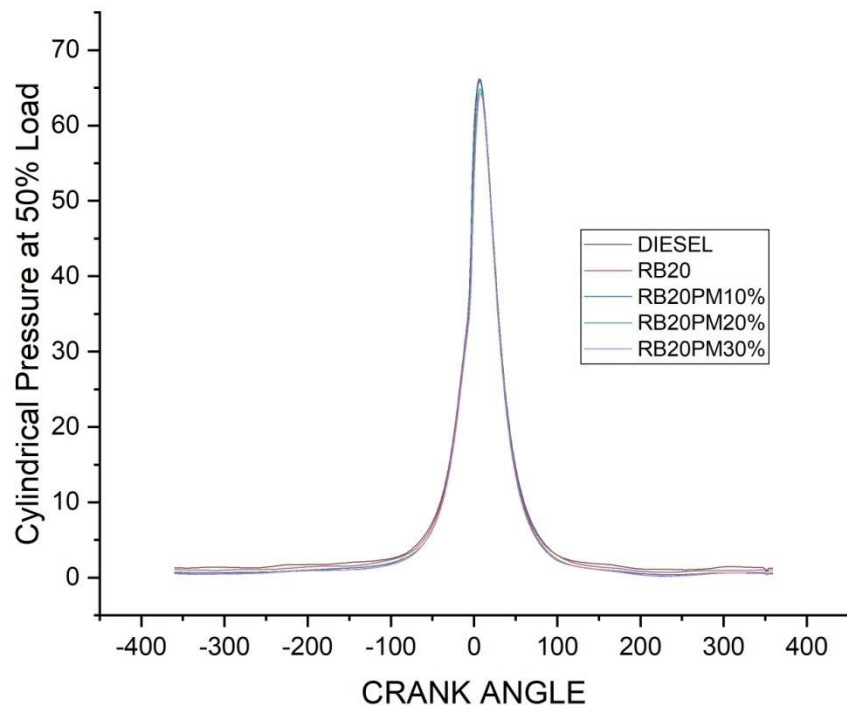


fig 5.12 cylindrical pressure at 50% load

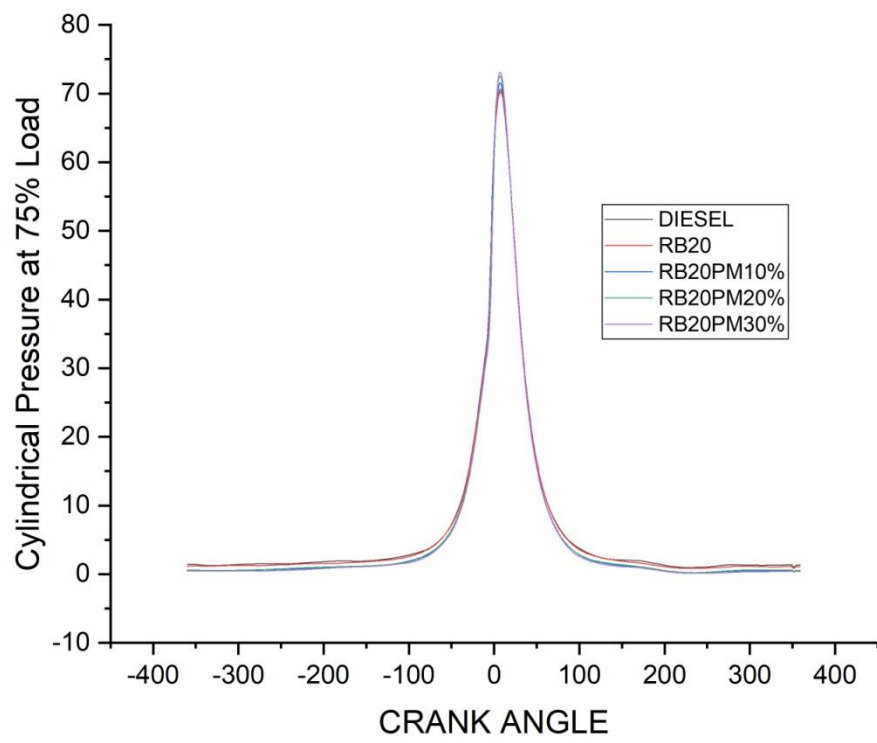


fig 5.13 cylindrical pressure at 75% load

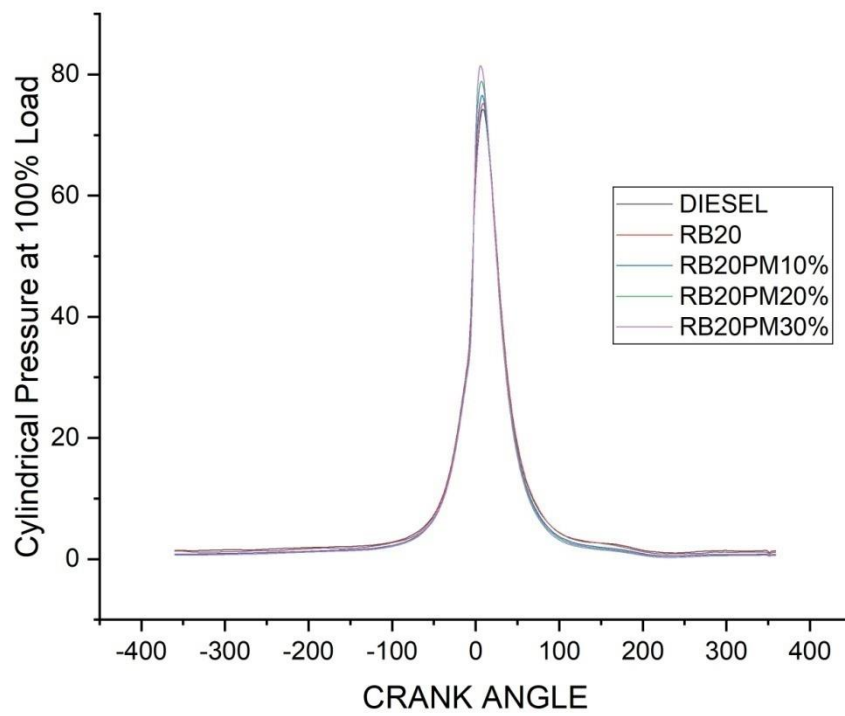


fig 5.14 cylindrical pressure at 100% load

5.4.2 Crank angle vs net HR $dQ_n/d\phi$

The net heat release depends on the crank angle. As we can see that DIESEL has the highest net heat release in 0% load followed by RB20-PM10% and the lowest is RB20. By increasing the load to 25% we can see the fluctuations of diesel at certain crank angles, RB20 also has more fluctuations as diesel. RB20 has highest net heat release, the lowest is DIESEL. At 50% load DIESEL has the highest net heat release followed by RB20-PM20% and DIESEL has the lowest net heat release, we can observe that DIESEL has more fluctuations in every load. At 75% load RB20-PM20% has highest net heat release followed by RB20-PM20% and DIESEL has the lowest heat release. At 100% load RB20-PM30% has highest net heat release followed by RB20-PM20%, at certain load RB20-PM30% net heat got decreased but finally the lowest net heat release is for DIESEL.

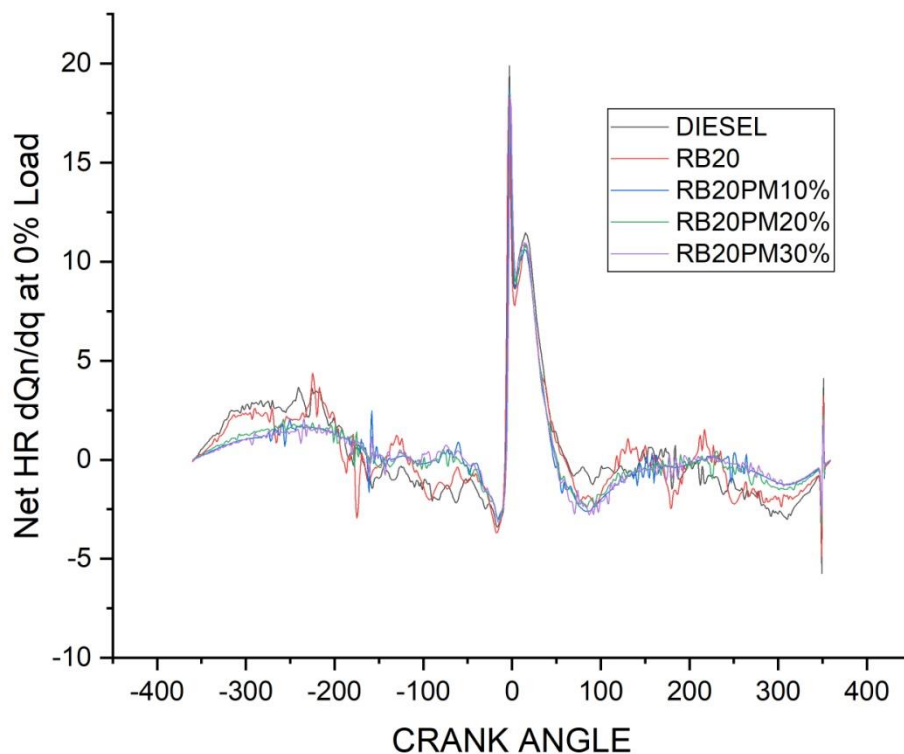


Fig 5.15 net heat release at 0% load

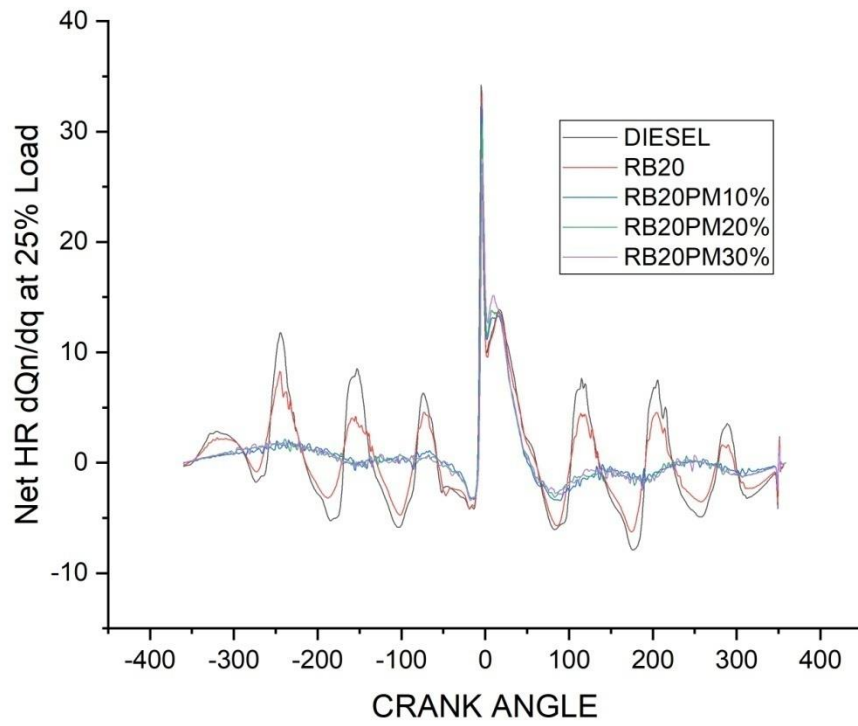


fig 5.16 net heat release at 25% load

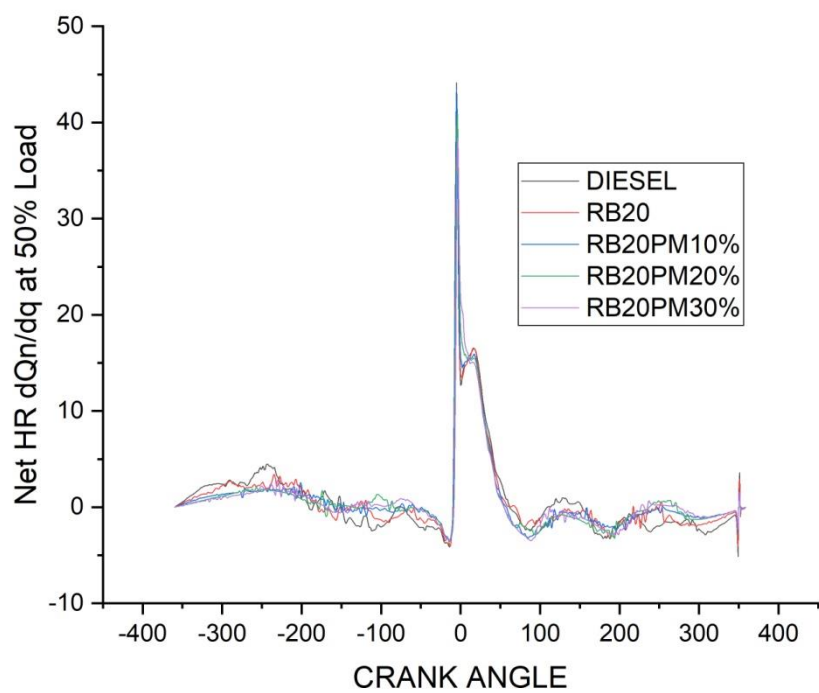


fig 5.17 net heat release at 50% load

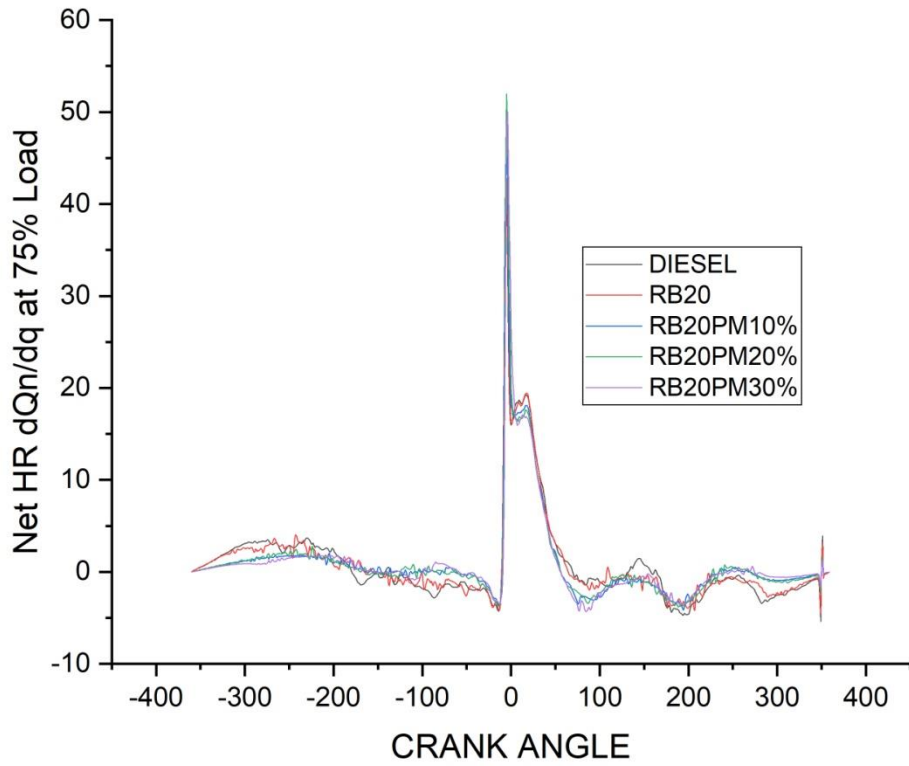


fig 5.18 net heat release at 75% load

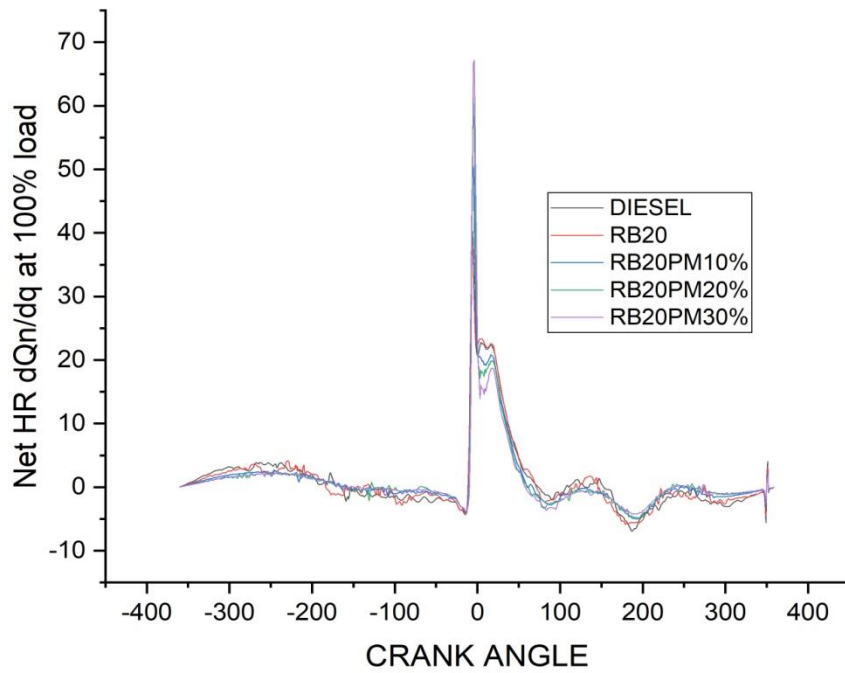


fig 5.19 net heat release at 100% load

CHAPTER 6

SUMMARY AND CONCLUSIONS

- The rice bran oil biodiesel is prepared successfully according to the standards.
- The high performance blend was prepared and tested physical and chemical properties.
- The high performance fuel blend is tested at different premixed charges at different loads.
- The brake thermal efficiency is found to be very high for RB20-PM30%
- The volumetric efficiency is found to be very high for RB20-PM10% and low for DIESEL
- RB20-PM30% has shown improvement in emission characteristics by lowering the carbon monoxide and carbon dioxide through out the different loads.
- NO_x emissions was lowest in case of diesel followed by RB20-PM30%
- Hydrocarbon emission was highest in case of RB20-30%

CHAPTER 7

REFERENCES

1. Agarwal, A.K. and Dhar, A., Comparative performance, emission, and combustion characteristics of rice-bran oil and its biodiesel in a transportation diesel engine, J. Eng. Gas Turbines Power, vol. 132, pp. 64503-1–64503-4, 2010.
2. Andreas, V., E. Rolf, and J. Bengt. 2008. Combustion chamber geometry effects on the performance of an ethanol fueled HCCI engine. SAE Paper No. 2008–01–1656.
3. Aoyama, T., Y. Hattori, and J. Mizuta. 1996. An experimental study on premixed-charge compression ignition gasoline engine. SAE Paper No. 960081.
4. Araki M, Umino T, Obokata T, Ishima T, Shiga S, Nakamura H. Effects of compression ratio on characteristics of PCCI diesel combustion with a hollow cone spray. SAE Technical Paper 2005; 2005-01-2130.
5. Balusamy, T. and R. Marappan. 2010. Effect of injection time and injection pressure on CI engine fuelled with methyl ester of thevetia peruviana seed oil. International Journal of Green Energy 7(4):397–409.
6. Bendu H, Murugan S. Homogeneous charge compression ignition (HCCI) combustion: mixture preparation and control strategies in diesel engines. Renew Sustain Energy Rev 2014;38:732–46.
7. BIS Code No. 13018. 1990. Internal Combustion Engine}Method of Test for Pressure Charge Engine. Kumar MS, Ramesh A, Nagalingum. 2001. Investigations on the use of Jatropha oil and its methyl ester as a fuel in a compression ignition engine. Journal of Institute of Energy 74:24–28.
8. Duc PM, Wattanavichien K. Study on biogas premixed charge diesel dual fuelled engine. Energy Convers Manag 1998;48(8):2286e308.

9. Elkelawy M, et al. Challenging and future of homogeneous charge compression ignition engines; an advanced and novel concepts review. *J Power Energy Syst* 2008;2(4):1108–19.
10. Elzahaby AM, et al. Kinetic modeling and experimental study on the combustion, performance and emission characteristics of a PCCI engine fueled with ethanoldiesel blends. *Egypt J Pet* 2018
11. Ganesh V, Deshpande S, Sreedhara S. Numerical investigation of late injection strategy to achieve premixed charge compression ignition mode of operation. *Int J Engine Res* 2015;17(4):469–78.
12. Hildingsson, L., Kalghatgi, G., Tait, N., Johansson, B. et al., “Fuel Octane Effects in the Partially Premixed Combustion Regime in Compression Ignition Engines,” SAE Technical Paper 2009-01-2648, 2009, doi: 10.4271/2009-01-2648.
13. Horibe N, Harada S, Ishiyama T, Shioji M. Improvement of premixed charge compression ignition based combustion by two-stage injection. *Int J Eng Res* 2009;10.
14. Jain A, Singh AP, Agarwal AK. Effect of fuel injection parameters on combustion stability and emissions of a mineral diesel fueled partially premixed charge compression ignition (PCCI) engine. *Appl Energy* 2017;190:658–69
15. Jayaprabakar, J., A. Karthikeyan, K. Gokul Kannan, and A. Ganesh. 2015a. “Experimental Investigation on the Performance and Emission Characteristics of a CI Engine with Rice Bran and Micro Algae Biodiesel Blends.” *Journal of Chemical And Pharmaceutical Sciences* 7: 68–71.
16. Jayaprabakar, J., and A. Karthikeyan. 2016. “Performance and Emission Characteristics of Rice Bran and Alga Biodiesel Blends in a CI Engine.” *Materials Today: Proceedings* 3 (6): 2468–2474. doi:10.1016/j.matpr.2016.04.164.
17. Kalghatgi, G.T., Hildingsson, L., Johansson, B. and Harrison, A.J., “Low-NOx, low-smoke operation of a diesel engine using “premixed enough” compression ignition - Effects of fuel auto-ignition quality, volatility and aromatic content”, *THIESEL* 2010

18. Kalghatgi, G.T., Hildingsson, L., Johansson, B., and Harrison, A.J., "Auto-ignition quality of gasolines in partially premixed combustion in diesel engines", *Proceedings of the Combustion Institute* 33, 2010.
19. Kanda T, Hakozaki T, Uchimoto T, Hatano J, Kitayama N, Sono H. PCCI operation with early injection of conventional diesel fuel. *SAE Technical Paper* 2005; 2005-01-0378.
20. Kook S, Bae CS. Combustion control using two-stage diesel fuel injection in a single-cylinder PCCI engine. *SAE Trans* 2004;113(3):563–78
21. Korakianitis, T., Namasivayam, A.M., and Crookes, R.J., Diesel and rapeseed methyl ester (RME) pilot fuels for hydrogen and natural gas dual-fuel combustion in compression–ignition engines, *Fuel*, vol. 90, no. 7, pp. 2384–2395, 2011.
22. Lü X-C, et al. Study on the Ignition, Combustion and Emissions of HCCI Combustion Engines Fueled With Primary Reference Fuels. *SAE International*; 2005
23. Nabi, M.N., Rahman, M.M., and Akhter, M.S., Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions, *Appl. Thermal Eng.*, vol. 29, nos. 11–12, pp. 2265–2270, 2009.
24. Saravanan, S., Pitchandi, K., and Suresh, G., An experimental study on premixed charge compression ignition-direct ignition engine fueled with ethanol and gasohol, *Alexandria Eng. J.*, vol. 54, no. 4, pp. 897–904, 2015.
25. Stanglmaier RH, Roberts CE, Homogeneous Charge Compression Ignition (HCCI): Benefits, Compromises, and Future Engine Applications. 1999, *SAE International*.
26. Vedharaj S, et al. Fuel Effect on Combustion Stratification in Partially Premixed Combustion. *SAE International*; 2017.
27. Yao M, Zheng Z, Liu H. Progress and recent trends in homogeneous charge compression ignition (HCCI) engines. *Prog Energy Combust Sci* 2009;35(5):398–437.
28. Yoon SH, Kim HJ, Park S. Study on optimal combustion strategy to improve combustion performance in a single-cylinder PCCI diesel engine with different combustion chamber geometry. *Appl Therm Eng* 2018;144:1081–90.

29. Zehni A, Khoshbakhti Saray R, Poorghasemi K. Numerical comparison of PCCI combustion and emission of diesel and biodiesel fuels at low load conditions using 3D-CFD models coupled with chemical kinetics. *Appl Therm Eng* 2017;110:1483–99.
30. Jayaprabakar, J., A. Karthikeyan, A. Josiah, and A. Shajan. 2015b. “Experimental Investigation on the Performance and Emission Characteristics of a CI Engine with Rice Bran and Micro Algae Biodiesel Blends.” *Journal of Chemical And Pharmaceutical Sciences* 7: 19–22.
31. Ju, Yi- Hsu, and Shaik Ramjan Vali. 2005. “Rice Bran Oil as a Potential Resource for Biodiesel.” *Journal of Scientific & Industrial Research* 64: 866–882.
32. Ju, Yi-Hu, and Shaik Ramjan Vali. 2005. “Rice Bran Oil as a Potential Resource for Biodiesel: A Review.” *Journal of scientific and Industrial Research* 64: 866–882
33. Velappan, Kandukalpatti Chinnaraj. 2007. “Less NOX Biodiesel: CI Engine Studies Fuelled with Rice Bran Oil Biodiesel and its Five Blends.” *Journal of scientific and Industrial Research* 66: 60–71.

