

EXPERIMENTAL STUDY OF DIFFERENT COMBUSTION CHAMBER GEOMETRY WITH RICE BRAN OIL BIODIESEL BLEND AND DIESEL

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

By

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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March 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of M.V.Trivikram Naidu (37150122) and Sareddy Anil Reddy (37150168) who carried out the project entitled **“EXPERIMENTAL STUDY OF DIFFERENT COMBUSTION CHAMBER GEOMETRY WITH RICE BRAN OIL BIODIESEL BLEND AND DIESEL”** under my supervision from October 2019 to April 2020.

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DECLARATION

We, M.V.Trivikram Naidu (37150122) and Sareddy Anil Reddy (37150168) hereby declare that the Project Report entitled **“EXPERIMENTAL STUDY OF DIFFERENT COMBUSTION CHAMBER GEOMETRY WITH RICE BRAN OIL BIODIESEL BLEND AND DIESEL”** 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 fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE:

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1.

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ABSTRACT

The study is conducted on the CI engine with a fuel blend consists of biodiesel, rice bran oil, and straight diesel along with varied combustion chambers the following conclusions are made. The present study which includes a high-performance diesel blend is prepared, with the constituents in the ratio of 80% diesel+20% rice bran oil. The blend is prepared as per the American Society for Testing and Materials (ASTM) standards. The properties are within the suggested limits. The experimentation conducted on a four stroke, single cylinder vertical water cooled diesel engine. Three types of combustion chambers (hemispherical, toroidal, reentrant) are tested along with b20 rice bran oil blend. The results are compared between within three combustion chambers. The performance characteristics stated the prepared blends shows slightly lesser performance values compared with diesel. The Brake Thermal Efficiency (BTE) is improved in hemispherical combustion chamber. As a penalty NO_x emissions were increased since B20 combustion chambers promoted better combustion. But the Specific Fuel Consumption (SFC) is less at toroidal and re entrant combustion chambers. The CO_2 Hydrocarbon emissions and smoke opacity values were increased in different combustion chambers. The prepared blend can be used in a CI engine by different combustion chambers for improving the performance and combustion characteristics.

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LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOL	ABBREVIATIONS
B20	20% biodiesel and 80% diesel
ASTM	American Society for Testing and Materials
BSFC	Brake specific fuel consumption
BTE	Brake Thermal Efficiency
CO ₂	Carbon Dioxide
CO	Carbon Monoxide
CP	Cylindrical Pressure
EGR	Exhaust Gas Re circulation
EGT	Exhaust gas temperature
HCC	Hemispherical Combustion Chamber
HC	Hydro carbons
Net HR	Net Heat Release rate
NO _x	Oxides of nitrogen
DP/Dq	Pressure Rise
RCC	Re Entrant Combustion Chamber
SFC	Specific fuel Consumption
TCC	Toroidal Combustion Chamber

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CHAPTER 1

INTRODUCTION

1.1 HISTORY AND BACKGROUND

The internal-combustion engine was first developed in the 19th century as a result of proper scientific understanding of the principles of thermodynamics and also the determination of engineers to find a substitute for steam power engines. In an internal-combustion engine the fuel is burned inside of the engine: the cannon provided is an early example of a single-stroke engine, several people have experimented with gunpowder as a means of driving a single piston in a cylinder. The major problem was that there was no suitable fuel for this process, and the other problems was that of igniting the fuel in an enclosed space and quickly and easily repeat it. The first problem was solved in the mid-19th century by the introduction of town gas supplies, but the second problem proved more harder to solve as it was difficult to maintain ignition evenly. The first successful gas engine was made by Étienne Lenoir in Paris in 1859. It was almost similar to a horizontal steam engine, with an explosive mixture of gas and air which was ignited by an electric spark on alternate sides of the piston when the piston was in middle of a stroke. Although the engine was technically satisfactory, the engine was very expensive to operate and it could not be used commercially. The German inventor Nikolaus August Otto refined this model in 1878 and only after that the gas engine became a commercial success. The CI engines are most commonly used in automobiles are for transportation applications. The advantages with CI engines are reduced emissions, an increase in reliability and a decrease in maintenance very good fuel economy. Each country share of CO₂ emissions are shown in Fig 1.1. To overcome these type of situations we need to find an alternative fuel which will be low cost, nonedible and renewable. Many alternative fuels have been discovered to either replace diesel fuel partially or completely. Bio fuels can be used as a promising alternatives to diesel. In the year 1853 scientists E. Duffy and J. Patrick conducted the transesterification of a vegetable. This was

many years before the first diesel engine even become serviceable. The history of bio diesel began in 1890's when "Rudolf Christian Karl Diesel" designed the compression ignition (C.I.) engine. Rudolf's first exhibition of the diesel engine was put on display on the World's fair in Paris 1898 and ran the engine with peanut oil (Vegetable oil).

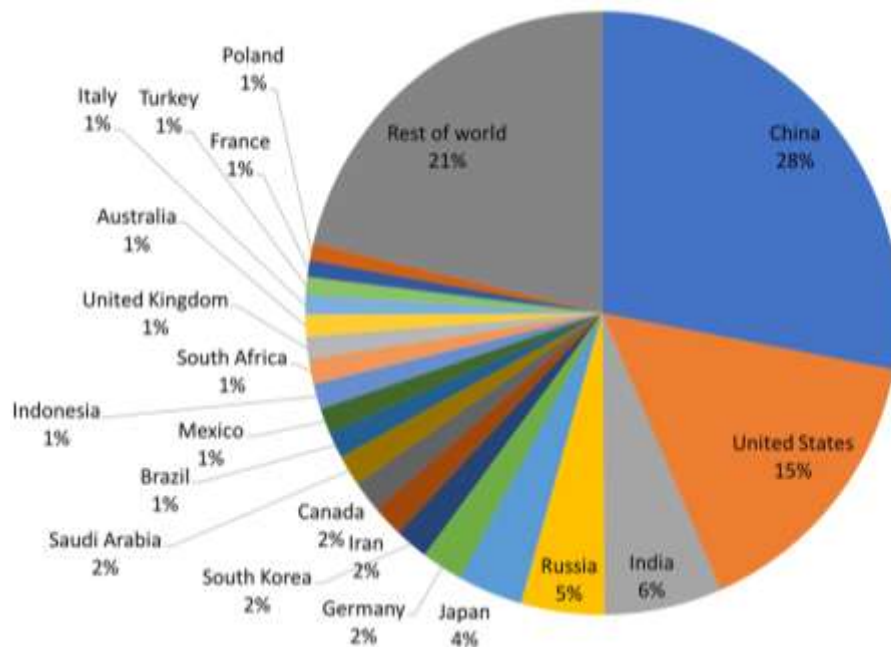


Fig: 1.1: Each Countries Share of CO₂ Emissions.

"The use of Vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and coal -tar products at the present time."(Rudolf 1920). The blending of the diesel with higher alcohols also will reduce the emission levels and improves the engine performance .So the fuel blend which gives good performance and emission results known as the high performance fuel blend. The high performance fuel blend include diesel, higher alcohol, biodiesel and vegetable oil. This high performance fuel blend can be the best alternative for the diesel as the performance of the engine increases and also the emission levels will reduce while compare to the fossil fuels and can be used in the compression ignition engine without any modifications.

Biodiesel is a renewable alternative fuel created from vegetable oils, animal fats and greases through a chemical process. Biodiesel was first developed by Rudolph diesel in 1890; he used pure vegetable oils in diesel engines. This was done in places where petroleum was not easily available. Modern biodiesel fuel is an outcome of research conducted in 1930s in Belgium, which is made by converting vegetable oils into compounds called fatty acid, methyl esters. Process of transesterification is used to convert vegetable oils into fatty acid alkyl esters and use as diesel fuel replacement with lower viscosity of vegetable oil. Concerns over environment, energy security and use of agro products saw an increase in the use of vegetable oils.

Advantages:

- It is renewable & energy efficient.
- It can be used as a 20% blend in most diesel equipment with no or only minor modifications.
- It reduces tailpipe emissions, including air toxics.
- It reduces global warming gas emissions.
- It is nontoxic, biodegradable and suitable for sensitive environments.
- Biodiesel is most commonly used as a blend with petroleum diesel. At concentrations of up to 5 vol % (B5) in conventional diesel fuel.
- B20 is the most commonly used biodiesel blend in the United States because it provides a good balance between material compatibility, cold weather operability, performance, emission benefits and costs.

1.2 BIODIESEL HISTORY

Biodiesel is typically a form of diesel which is rich in oxygen content and consists of a long chain of fatty acid esters. This biodiesel was first made with vegetable oil by transesterification process in the year 1853 by Patrick Duffy. This

was prepared four decades even before the first diesel engine was invented. The first diesel engine was invented in by Rudolf Diesel and it was made to run on biodiesel obtained from groundnut oil for the first time in 1893. At that time Rudolf Diesel has foreseen that in the course of time biodiesels will become as important as petroleum diesel. Biofuels made from plants are abundantly found on earth, their only source of energy is sunlight which is abundant. These plants absorb carbon dioxide and produce oxygen in return. So the oils derived from plants are rich in oxygen content. When these oils are made into biodiesel and used will show good emission characteristics. By the fact that the fossil fuel reserves are getting exhausted, the demand for production of biodiesel has increased in many countries. Biodiesel is produced from the used cooking oil or non-edible oil by the process called transesterification. In this process the base oil is mixed with alcohols and catalyst to for biodiesel

1.2.1 *Necessity for Bio Diesel*

H.K.Rashedul, et.al (2014), Biodiesel is prepared to mainly use it in diesel engines, because the engine performance has to be compared with conventional diesel. The main usage of bio diesel is used to reduce the emissions and also these fuels give a number of advantages where these fuels are not explosive, nonflammable and non-toxic and also bio degradable. Compare to these advantages there are some disadvantages too. Some bio diesels give NOx emission which are so harmful to environment, and the flow properties are very poor in low temperatures. The usage of biodiesel can be one form of considering economic factors where the conventional fuel prices are high and also they affect to the environment and cause damage to the ozone layers causing to severe accidents. It is so difficult for the poor countries to buy these conventional fuels so there is a need to use bio fuel which are economical in terms of cost and not causing harm to environment .Due to this reason biodiesel has to be used.

1.3 BIODIESEL SOURCES AND ITS CLASSIFICATION

The alternative sources of fossil fuels is studied because of great need to control the consumption of non-renewable fossil fuels. Bio fuels have been classified into two types they are primary and secondary sources. The primary

sources of bio fuels consists of fire wood, wood chips, pellets, animal wastes, forest and crop residues, landfill gas. These primary sources are in use for the older generations. In the new era the secondary sources are used for producing bio diesel and they are divided into first, second, third generations respectively.

1st generation bio fuels are made up by the bio ethanol or butanol which are produced from the fermentation of starch such as wheat, barely, corn, potato, sugar. And also from the oil crops, waste cooking oil, animal fats etc.

2nd generation bio fuels are produced from the oil plants such as Jatropha, Cassava, elephant grass and also from lignocellulosic materials like straw, wood and grass.

John R.P, et.al. (2011) 3rd generation bio fuels are produced from the extracting oil of algae sometimes referred as “Oilgae”. Its production is supposed to be low cost and high yielding. Algae is the most economical and environmental sustainable and also renewable source of bio mass which can be used in the production of bio fuels.

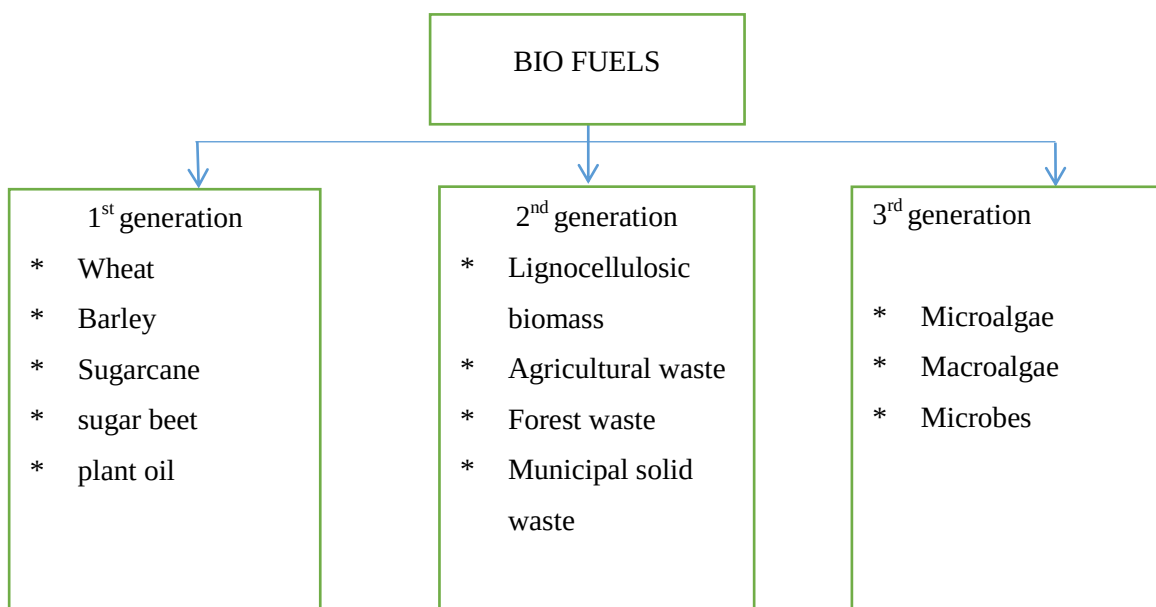


Fig: 1.2: Generations of Biodiesel

1.4 METHODS TO PRODUCE BIODIESEL

There are many ways to produce biodiesel. Usually biodiesel is made through chemical reaction of transesterification and esterification process, that is reaction of vegetable oils with short-chain alcohols (like methanol or ethanol). The catalyst required for production of biodiesel are either base catalyst or acid catalyst. Most commonly used catalyst are base type because of its lower reaction time and low cost. There are three major steps to produce Biodiesel that is:-

i. Transesterification process

Oils derived from plants or animals are usually composed of triglycerides. These triglycerides react with alcohol such as ethanol or methanol to produce ethyl esters (biodiesel) and glycerol(byproduct). Most of the biodiesel is produced from virgin oils using base-catalyzed transesterification process as it is economical process for treating vegetable oils. As virgin oils require low temperatures and pressures for producing biodiesel is economical.

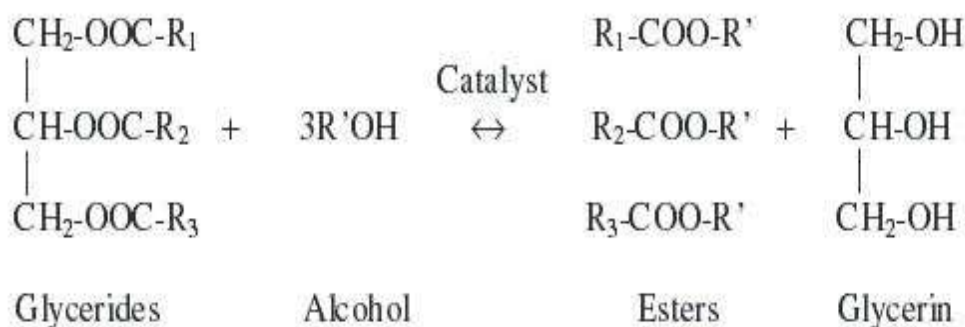


Fig: 1.3: Transesterification process

1.5 INFORMATION ABOUT BLENDS

Rodica Nieuleacu, et.al, (2019) The bio diesel can be blended in many different proportions which can be used in different concentrations the most commonly used bio diesel blends are B5 (up to 5% bio diesel) and B20 (20% bio diesel), B100 which is the pure form of bio diesel used as a blend stock for lower

blends and hardly can be used for transportation purpose. Blending of diesel with bio diesel is used to improve the bio diesel properties and has many benefits. Up to 30% bio diesel can be blended in diesel fuel and directly used in C.I. engines without any modifications .

Lapuerta,M.et.al (2010),The diesel and bio ethanol blend can be used as alternative as a renewable fraction in automobiles which will grow attention in economic and environmental advantages. The stability will increase when biodiesel is added to the diesel fuel and while adding the alcohols to the blend will loss lubricity of the fuel blend. Alpaslan Atmanli (2016).,Higher alcohols such as propanol, n-butanol and 1-pentanol can be added to diesel-biodiesel blend for improving cloud point, cold filter plugging point and leads to the reduction of density, lower heating value, kinetic viscosity, Cetane number, and flash point . Nadir Yilmaz,et.al (2014) By adding the vegetable oil to diesel-biodiesel-alcohol blends can increase the CO and HC emissions but it reduces the NOx emission

1.5.1 Combustion Chambers

An internal combustion engine in which the combustion air/fuel blend is burnt comprises a combustion chamber. For steam engines, this term is often used to extend the firebox to enable a more complete combustion operation.

The pressure generated by the mixture of combustible air/fuel applies in an inner combustion engine directly to part of the engine (for example, a column engine has the force applied to the top of the piston) (often in the form of a rotating output shaft). This compares an external combustion engine in which the combustion occurs in a single section of the engine in which the gas pressure is transformed.

The combustion system inside the motor barrel mainly depends on the shape and design of the combustion chamber. In the current research, the performance, outflow and light attributes of a turbo-charged single diesel cylinder motor powered by biodiesel are investigated carbon and producer gas injected as fuel by adjusting the geometry of the combustion chamber.

- HEMI SPHERICAL PISTON
- TOROIDAL PISTON
- RE ENTRANT PISTON

HEMISPHERICAL COMBUSTION CHAMBER :

A hemispheric combustion chamber is a type of combustion chamber with an approximate hemisphere shape in a reciprocal internal combustion engine with a domed cylinder head. A hemispheric chamber-style engine is known as a hemi engine.

Hemispherical PISTON

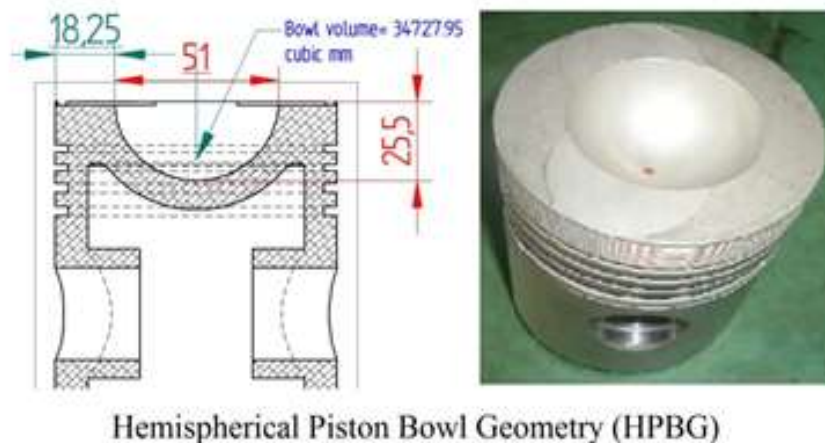


Fig: 1.4: Hemispherical piston bowl geometry

TOROIDAL COMBUSTION CHAMBER :

For an opposing piston engine a toroidal combustion chamber shape is seen with a side injection. In one form, each injector is injected with fuel a multitude of times, in order to allow fuel clouds from each injection to be significantly separated from each other.

Toroidal PISTON



Fig: 1.5: Toroidal piston bowl geometry

RE ENTRANT COMBUSTION CHAMBER :

To provide a combustion chamber type to minimise smoke, NO_x and particulates generation through a distorted lip-generated flux in the cavity port, allowing the fuel injection mist in laminary form to cross.

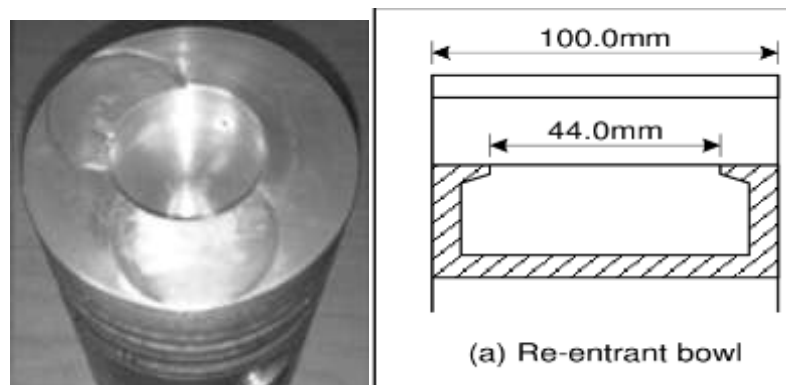


Fig: 1.6: Re Entrant piston bowl geometry

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Many number of researches have already done to the production of biofuels, properties and their performance in diesel engine, even so many number of researches have done on the biodiesel preparation from Rice bran oil but very few number of literature reviews are investigated on the usage of Rice bran oil biodiesel blends in C.I. engine about 190 research papers have been published in famous international journals and conferences on performance, combustion and emission characteristics of biodiesel-diesel blends. We referred many research papers and selected high performance fuel as our primary blend. Even though many researches have been done on this fuel but few researches only performed on different combustion chamber geometry blend in order to increase the performance characteristics like volumetric efficiency, Specific fuel consumption, exhaust gas temperatures and to reduce the Carbon monoxide (CO), NO_x, HC and smoke exhaust emissions.

2.2 EFFECT OF COMBUSTION CHAMBER SHAPES ON CI ENGINE

Nataraj Kashipura, Banapurmath NR concluded that Combustion chamber shape plays an important part in regulating combustion processes and internal emission mechanisms the chamber of combustion. In this respect, A single four-stroke direct injection diesel engine powered in dual fuels has been carried out with an experimental investigation. Mode of Rice bran methyl ester (ROME) and Coconut wood shell derivative gas manufacturer. ROME is used as a fuel pilot which ignites the producer gas and air mix if the compression ratio is higher. The hemisphere combustion chamber (HCC) shape is used by the engine. Cylindrical (CCC), trapezoidal (TrCC) and Toroidal Combustion Chamber (TCC) have been used to examine the effect of the other combustion chamber forms on the output of dual fuel engines

Various parameters were calculated like power outlet, engine torque, combustion fuel and exhaust, combustion parameters including heat release rate, delays in ignition, period of combustion and exhaust emissions including smoke opacity, hydrocarbon, CO and NOx. The results showed that, compared with other forms studied, the TCC-form resulted in general improved efficiency and reduced emissions.

M. Channappagoudra, K. Ramesh investigated and found that The current diesel engine hemispheric piston bowl geometry (HPBG) was transformed into toroid piston bowl geometry (TPBG) to test the efficiency of a 20 per cent milking scum biodiesel engine (B20). The testing results show that brake thermal efficiency and heat release have increased by 5,5% and 17,24%, and that specific fuel, HC and CO emissions have been decreased by 8,75% and 15% respectively, while brake fuel consumption has decreased by 14,47%. This can be due to better fuel atomization, reduced droplet size, improved cylinder temperature, enhanced squishing capacity and turbulence during combustion, etc. TPBG enhancements may also be achieved. The results of the current study could pave the way to the development of bio-diesel-compatible diesel engines and their combinations. The improved use of TPBG could be due to improved atomization of the fuel, reduced fuel droplet, increased cylinder temperature, increased squishing of the fuel spirit and kinetic energy turbulence during the combustion process.

Swarup Kumar Nayak, Purna Chandra Mishra investigated and found that This paper describes the performance, emission, and combustion properties of a turbo-charged diesel (TDI) engine, operated in dual fuel modes using calophyll inophyll oil ester and babul wood chips produced by manufacturing gas, as the result of the injection parameter and combustion geometry. The results of experiments indicated that the thermal braking system with an advanced injection timing (IT) and injection pressure (IP) of 24°bTDC and 230 bar Overall reduction in productivity (BTE) was 6.35%, with an improvement of around 5.68% and 10.88% in brake Relevant intake of fuel (BSFC) and temperatures of exhaust gas (EGT).

2.3 EFFECT OF DIFFERENT TECHNOLOGIES ON COMBUSTION AND EMISSIONS OF THE CI ENGINE

Jiaqiang Ea,d , Minhhieu Pham investigated that Because of the lack of existing fossil fuels and combustion emissions, it is desperately important to have new, renewable and cleaner fuels. As a possible fuel and substitute, biodiesel has long been implemented. Biodiesel can be produced from various sources, including vegetable oils, animal fat, waste oil and so on. As biodiesel is used as fuel for diesel engines the performance and emissions characteristics like BTE, BSFC and brake power are almost retained as hydrocarbon (HC), carbon monoxide (CO) and particulate matter (P Material) are substantially reduced (PM). Biodiesel is also used as a fuel source for Diesel engines. Higher NO_x levels are observed, however. In recent years this inconvenience of the use of biodiesel or biofuels is improved.

2.4 EFFECTS OF HIGH PERFORMANCE FUEL IN A C.I. ENGINE.

Li, Li, Wang, Jianxin, Wang, zhi, Xio, Jianhua (2015) in a test they have studied that the addition of Pentanol to diesel and biodiesel blends in different proportions in the single cylinder direct injection diesel engine and reveal the effects of performance, combustion and emission. The Pentanol blends shows the high indicated thermal efficiency than pure diesel for all tested loads from 0.5 to 1 mpa. Finally it has resulted that with 40% diesel- 30% biodiesel – 30%pentanol gives the better combustion and emission characteristics along with economy performance compared to other fuels.

Alpaslan Atmanli (2016) did his work on to investigate and compare higher alcohols adding to diesel biodiesel blends results in positive economic and environmental outputs due to high cetane number and calorific value. The cloud point and cold filter plugging point improved where the density, heating value, kinetic viscosity, cetane number and flash point decreases slightly. Especially higher alcohol like 1-pentanol, has the most effective results which reduces the oxides of nitrogen while compared to n-butanol and propanol.

2.5 EFFECT OF BIODIESEL IN A C.I. ENGINE.

Maginlapuerta, Jose M. Herreros (2008) reported that the alcohol derives biodiesel fuels like methyl ester and ethyl ester extracted from Waste cooking oil. About 30% and 70% biodiesel blend with diesel on Volume basis and tested in common rail injection Compression Ignition engine. This report shows the results of slight increase in consumption of fuel, less difference in NO_x emission and tremendous control of hydrocarbon emissions, smoke and particle emissions.

Mangesh G Kulkarni and Ajay K Dalai (2006) stated that biodiesel is a non-toxic and bio degradable alternative fuel which is prepared from the renewable sources. Out of the many economical sources for biodiesel Waste cooking oil is the best Source as its cost is comparatively very less than petroleum based Diesel fuel. Waste cooking oil biodiesel when tested on Commercialized diesel engines shows better engine performance and very low emissions.

Ozer Can (2014) have performed the research on waste cooking oil biodiesel blends with diesel fuel in Compression Ignition engine. The performance of engine and combustion results showed that at all engine loads while adding the biodiesel the ignition delay occurs due to biodiesel fuels having high cetane number. Also addition of biodiesel results in less increase on Brake specific fuel consumption and reduces the Brake thermal efficiency but the HC and smoke emissions are reduced highly.

Xiangmei Meng, Guanyi Chen, Yonghong Wang (2008) have tested the B20 (20% Biodiesel), B50 (50% Biodiesel), blends of waste cooking oil bio diesel in a C.I. engine and analyzed the performance, combustion and emission characteristics. This investigation revealed that B50 blend fuels showing the unsatisfied emissions. Whereas B20 blend fuels showing the reduced HC and CO emissions.

2.6 SUMMARY OF LITERATURE REVIEW

Many literatures have been reviewed and studied thoroughly and the group of results have arrived from the literatures. The current research work has many methodological facts and based on that the conclusions are incorporated. The outcome results and conclusions are as follows:

- Without any modification in C.I engines the biodiesel obtained from the renewable sources like animal fats and plant seeds can act as an alternative fuel.
- To replace the harmful fossil fuels the alternative biofuels should be produced from low cost feed stock and renewable sources like waste cooking oil, Jatropha seeds.
- B20 blend which consists of 80% diesel and 20% biodiesel is best blend as it reduces the CO,HC,NOX emissions highly when compared to diesel fuels
- The performance characteristics like brake thermal efficiency decrease and specific fuel consumption increases but the emission levels are controlled in a great level on addition of biodiesel to diesel fuels.
- 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.

After investigating many literatures we get to know that so much of research have already done on the biodiesel blends. But there is very limited research done on the Different combustion chamber geometry. So this study is focusing on the performance, combustion, emission characteristics of the different blends.

CHAPTER 3

AIM AND SCOPE OF THE PROJECT

3.1 AIM OF THE PROJECT

- To produce biodiesel from Rice bran oil.
- To understand the combustion chambers, when feed with a bio diesel blend.
- To study the performance and emission characteristics of the biodiesel blend in a diesel engine along with combustion chambers.
- To compare performance and emission characteristics of a diesel engine operated with different combustion chambers.

3.2 SCOPE OF THE PROJECT

The combustion chamber geometry is an emission control technology allowing significant emission reduction from most types of diesel engines, As the emission levels of the fossil fuels is increasing day by day and they are non-renewable and harmful to the atmosphere, the renewable and ecofriendly alternative source of biodiesel can be used. Rice bran oil biodiesel is the best alternative in both economically and environmental basis. The blend of the Diesel, Rice bran oil will make the engine characteristics more accurate. This research work provides a solution of how compression ignition engine works by the addition of the different combustion chambers to the high performance blend.

CHAPTER 4

MATERIALS AND METHODS

The work has been classified into two stages:

- Preparation of biodiesel
- Engine testing analysis

4.1 MATERIALS

For the preparation of the blends alcohol, diesel, biodiesel, and oil are required. This procedure includes the usage of Rice bran as the oil, similarly, methanol is used as the alcohol used in this particular procedure. the detailed experimental methodology proposed for the researched work is illustrated in the fig 4.1, the details of materials required, methods applied, specifications of the instruments used, working principles and the experimental procedures by which the research has been conducted are explained in this chapter.

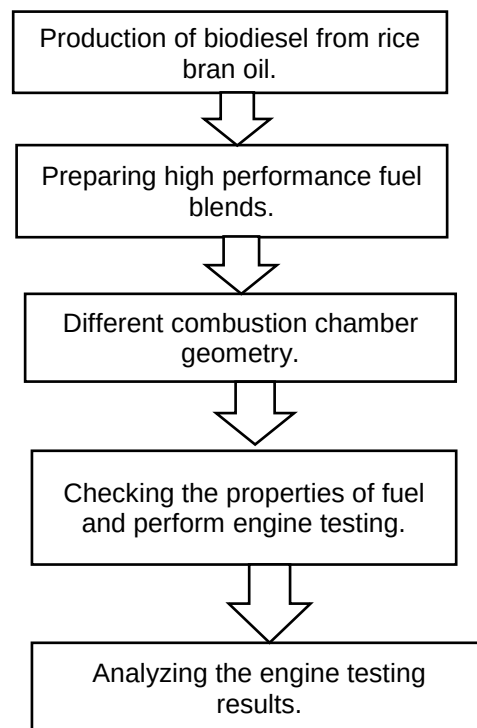


Fig: 4.1: Flow Chart of Experimental Methodology.

4.2 THE BIODIESEL PRODUCTION FROM WASTE COOKING OIL

The Rice bran oil and diesel is collected. The detailed biodiesel preparation process is explained in this section.

4.2.1 *Mixing of Catalyst to Alcohol*

Sodium hydroxide pellets (Caustic soda) is used as a catalyst in the work. These dry caustic pellets has to mix the methanol. In this work about 5grams (0.5 wt.% of rice bran oil) of NaOH pellets is mixed with the 182 ml of methanol (molar ratio of 1:6 to Rice bran oil) for about 90 minutes by using a magnetic stirrer. It was ensured that the dry NaOH pellets should completely mixed with the methanol.



Fig: 4.2: Mixing of Catalyst with alcohol

4.2.2 *Transesterification Process*

First we need to check for the free fatty acid content present in the oil. If the free fatty acid content is greater than 4% then the process we have to choose is a Transesterification process. Transesterification is the process of exchanging the organic group R'' of an ester with the organic group R' of an alcohol. These

reactions are often catalyzed by the addition of acid or base catalyst. It is a process in which the oil (tri glycerides) react with methanol in the presence of a catalyst of sodium hydroxide the gives rise to the methyl ester (biodiesel) and glycerin.



Fig: 4.3: Transesterification process.

As this transesterification process produces about 98% of the biodiesel yield which requires only low pressures and temperatures this process is considered as a most economical one and almost all type of biodiesels can be produced from this process. Take a conical flask and mix the 1litre of oil and the mixture of methanol and NaOH by using magnetic stirrer for 3 hours at 300rpm. The reaction temperature should maintain about 60⁰c throughout the reaction.

Table 4.1. Transesterification properties

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 %

4.2.3 Separation process

The reacted mixture is taken and poured into the two opening flask and settles down the mixture for about 15minute. Due to the gravity and higher density glycerin settles down at bottom of the flask and the methyl ester or biodiesel stays at the top of the conical separator flask. The glycerin can be easily drained out by using the opening valve at the bottom. As the two layers are clearly identified so we can easily separate the glycerin from methyl ester.



Fig: 4.4 : Separation of glycerin from Biodiesel.

4.3 PROCESS OF PREPARING FUEL BLENDS

As the pure diesel is giving more emissions and also it is biodegradable non-renewable fossil fuel. The alternative waste cooking oil is prepared by the transesterification process but that biodiesel cannot use directly in the compression ignition engine. So the biodiesel is blended with diesel and alcohol with some vegetable oil because this blend will give best performance, combustion and emission characteristics according to many literature papers. So the diesel is taken from the Indian petrol bunk near Satyabhama University. rice bran oil was bought from oil shop in Chennai. 500ml of three blends are prepared by adding diesel (80%), and 100 ml of rice bran oil biodiesel (20%). the components are measured by using measuring jar and using funnel the blends are prepared in a bottle. So totally 3 bottles of 500ml each blends are prepared.

Table 4.2: Properties of Blends

PROPERTIES	RB20	RB100	D100
DENSITY @20C,kg m ³	0.8524	0.882	0.845
Kinematic viscosity	1.69	8.4	0.84
Flashpoint,°C	153	221	52
Calorific value cal/g	9842.6+	8642.63	10143.916

4.4 ENGINE TESTING AND ANALYSIS

The experimental research is done in a single cylinder, four stroke diesel engine and it is connected to an eddy current type dynamometer for loading. For the combustion pressure and crank angle measurements it is provided with necessary instruments.

4.4.1 *Engine Details.*

The engine specifications that was used to carry out the various test are mentioned in the table

Table 4.3: Engine specifications

Cooling	Water-cooled engine
Model	Kirloskar TV1
No.of.Cylinders	1
Cubic Capacity (liter)	0.661
Rated Speed (rpm)	1500
Governing	Class "A2/B1"
Power	5.20KW
Power Rating	7 hp
Cylinder bore	87.50mm
Stroke length	110.00mm
Connecting rod length	234mm
Compression ratio	17.50
Swept volume	661.45cc
Over all dimensions	Width 2000*length2500*height1500mm.

4.4.2 Schematic Diagram of Engine

The schematic diagram of engine is shown in Fig 4.14.

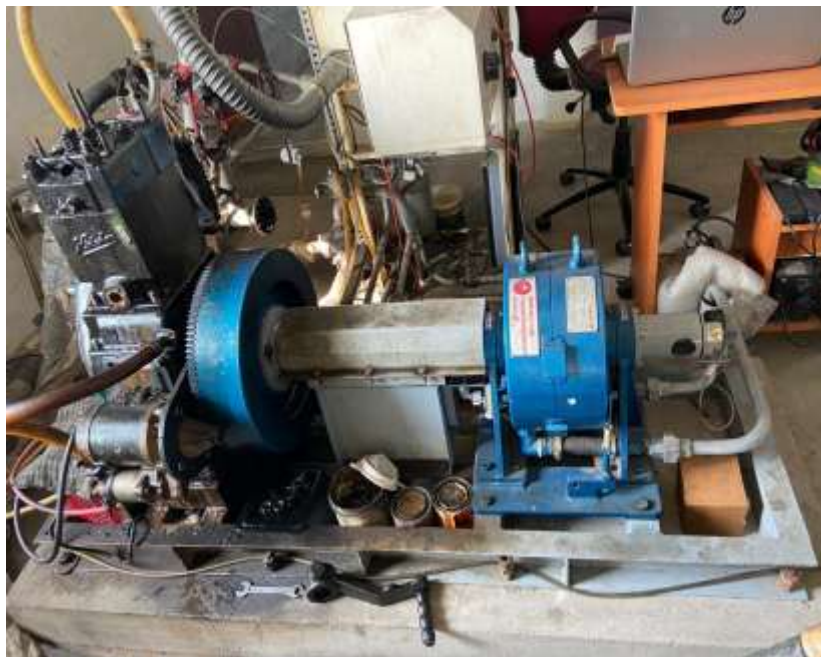


Fig: 4.5: Testing Engine.

4.4.3 TEST RIG COMPONENTS

The test rig consists of a single-cylinder four-stroke diesel engine which is connected to the following components in the order specified below

- Hydraulic dynamometer (engine loading)
- Panel box
- Airbox
- Fuel tank
- Manometer
- Fuel measuring unit
- Digital speed indicator
- Temperature indicator



Fig: 4.6: Smoke meter and Gas Analyzer

The fig 4.10 shows a gas analyzer and a smoke meter. The diesel exhaust smoke meters are also known as opacity meters which identify and measure the amount of light blocked in a sample of smoke given out by diesel engines. The smoke meter displays the smoke density giving the rate of the efficiency of the combustion. The smoke meter consists of an optical unit mounted inside a measuring head which also has a separate electrical control unit. The gas analyzers are of the principle that the absorption of light by the gas under test. The analyzer only needs to shine a beam of light via the unheated chamber then it is measured to understand how much, the specific wavelength was observed by the sample. The analyzer consists of an optical filter that cancels out all light leaving the wavelength that the selected gas molecule can observe. Other gas molecules will not absorb light at this particular wavelength, and they don't even affect the amount of light reaching the detector.

CHAPTER 5

RESULTS AND DISCUSSION

According to the objectives and methodology discussed, experimental investigations on the engine operated by a high-performance blend of diesel along with an B20 blend were conducted and the results are presented in this chapter. For comparison purposes, a normal engine was also tested for the same conditions (using the same blend of diesel). The results obtained from the experiments are presented and discussed through graphs. The performance parameters include brake thermal efficiency, specific fuel consumption, volumetric efficiency, and exhaust gas temperature. Cylinder pressure and heat release rate are used to measure the combustion nature of the engine. The emission parameters include carbon monoxide, unburnt Hydrocarbons, NO_x , and Smoke opacity and carbon dioxide

5.1 PERFORMANCE CHARACTERISTICS

Brake thermal efficiency, specific fuel consumption, and volumetric efficiency and exhaust gas temperature which are all the performance characteristics of the blended fuel are explained in this section

5.1.1 *Brake Thermal Efficiency*

Brake thermal efficiency (BTE) is utilized for evaluating the engines capability of converting the heat energy produced from the diesel fuel during combustion into mechanical energy. Brake thermal efficiency values are largely affected by fuel properties like heating value and density.

It is clear from the above graph that at zero load conditions the brake thermal efficiency is low and when the higher brake thermal efficiency is obtained, then there is an increase in load. BTE increased with increase in engine load. The BTE is less for b20 re entrant piston where as high for diesel

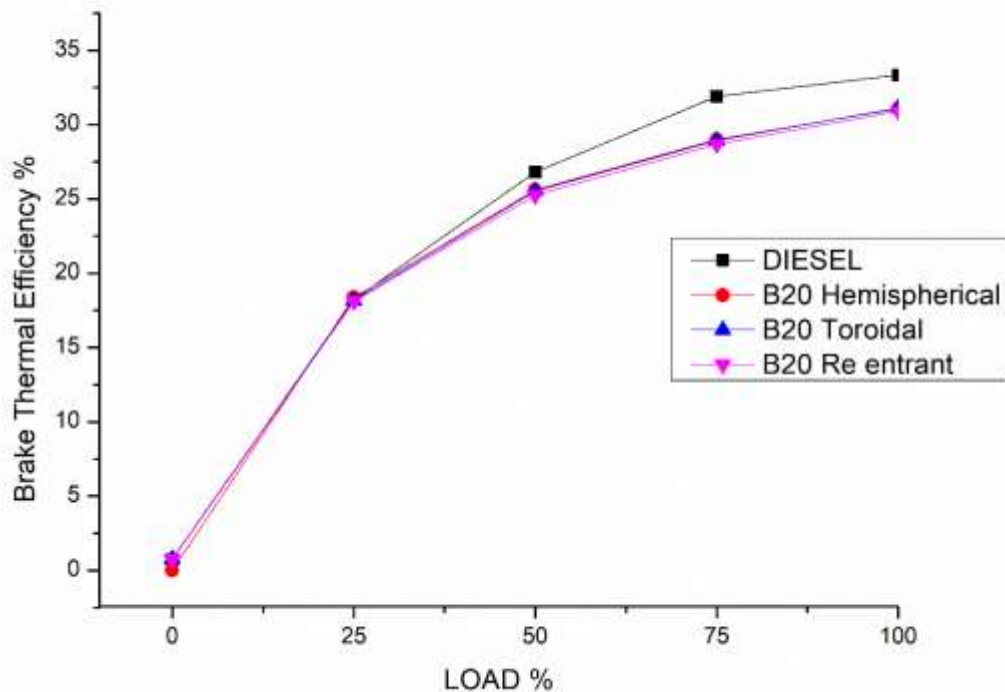


Fig: 5.1: Brake thermal efficiency.

5.1.2 Volumetric Efficiency

The ratio of the volume of fluid displaced by a piston or plunger to its swept volume is known as Volumetric efficiency. The volumetric efficiency of the engine normally depends on the ambient condition as well as its operating conditions.

Here, the above graph shows that

As the Load increases the volumetric efficiency decreases. It may be due to higher gas temperature and increase in temperature of inlet valve and combustion chamber walls. This feature decreases the density of induced air, and hence, the drop in volumetric efficiency. In case of TCC, at the end of compression stroke complete air-fuel mixture combination trapped in the cylinder and gets ignited immediately. However, slightly higher volumetric efficiency was observed with TCC compared to other combustion chamber shapes.

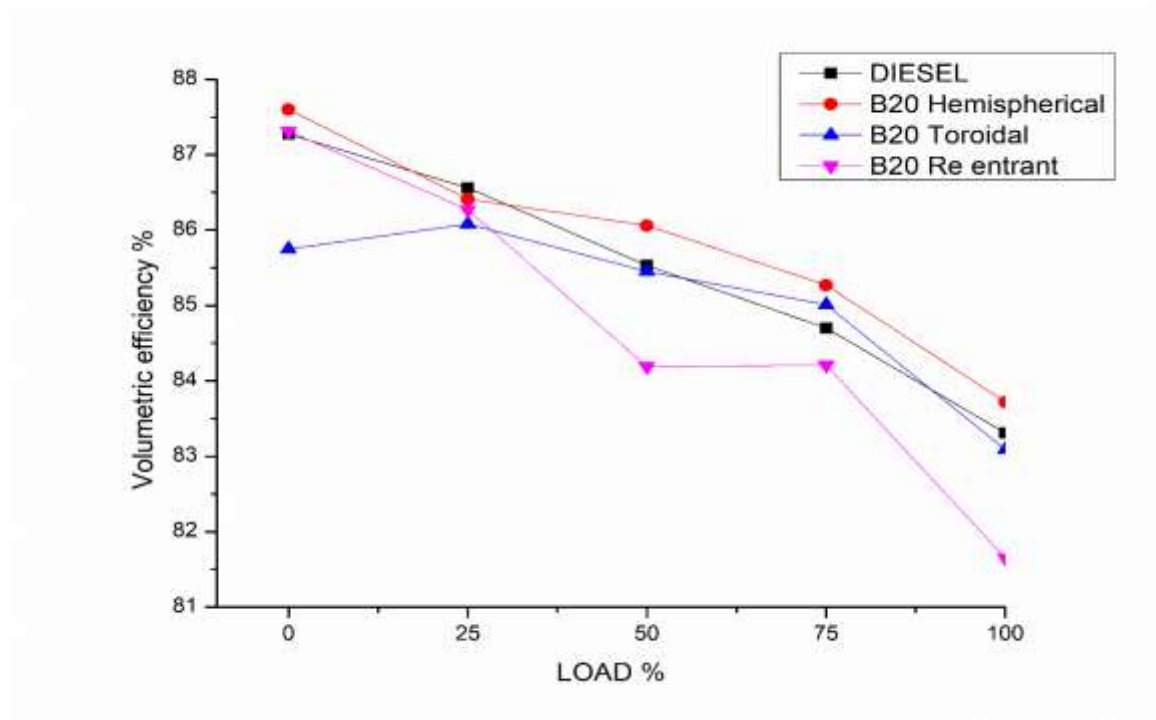


FIG: 5.2: Volumetric efficiency.

5.1.3 Brake specific fuel consumption

Brake-specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. It is the rate of fuel consumption divided by the power produced. It is viewed that with increment in load, BSFC for all test fuels with combustion chambers demonstrate a declining curve because of better combustion due to higher in-cylinder charge temperature. However, at highest loading condition, BSFC for all fuels with combustion chambers increases. The BSFC is lower for diesel and higher for toroidal and re entrant pistons.

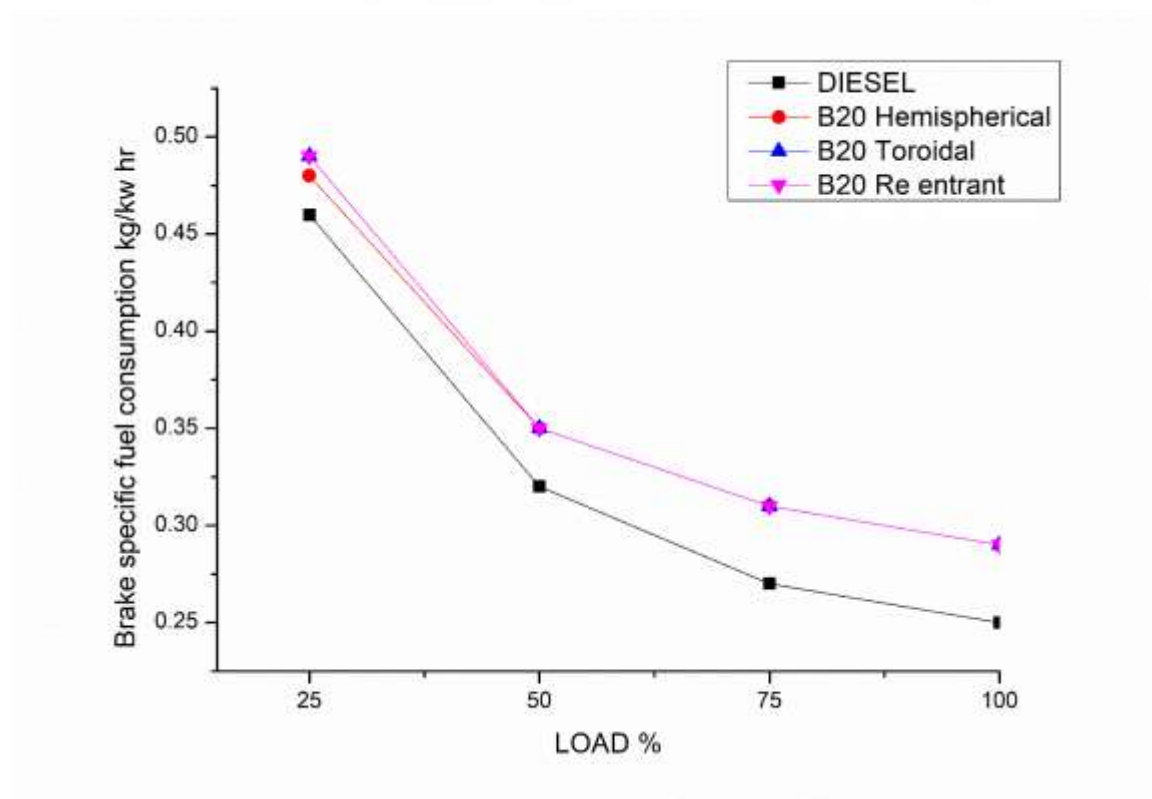


FIG: 5.3: Brake specific fuel consumption.

5.1.4 Exhaust Gas Temperature

EGT is a measurement of temperature of the exhaust gases at the exhaust manifold. As the temperature of the exhaust gas varies with the ratio of fuel to air entering the cylinders, it can be used as a basis for regulating the fuel/air mixture entering the engine.

The above graph represents the exhaust gas temperature at various loads. The graph shows that with an increase in load and by the process of combustion the exhaust gas temperature increases, The increase in the Exhaust gas temperature is directly proportional to the increase in the load. The graph shows that the exhaust gas temperature at 75% load of re entrant piston is quite higher than the same load of normal diesel.

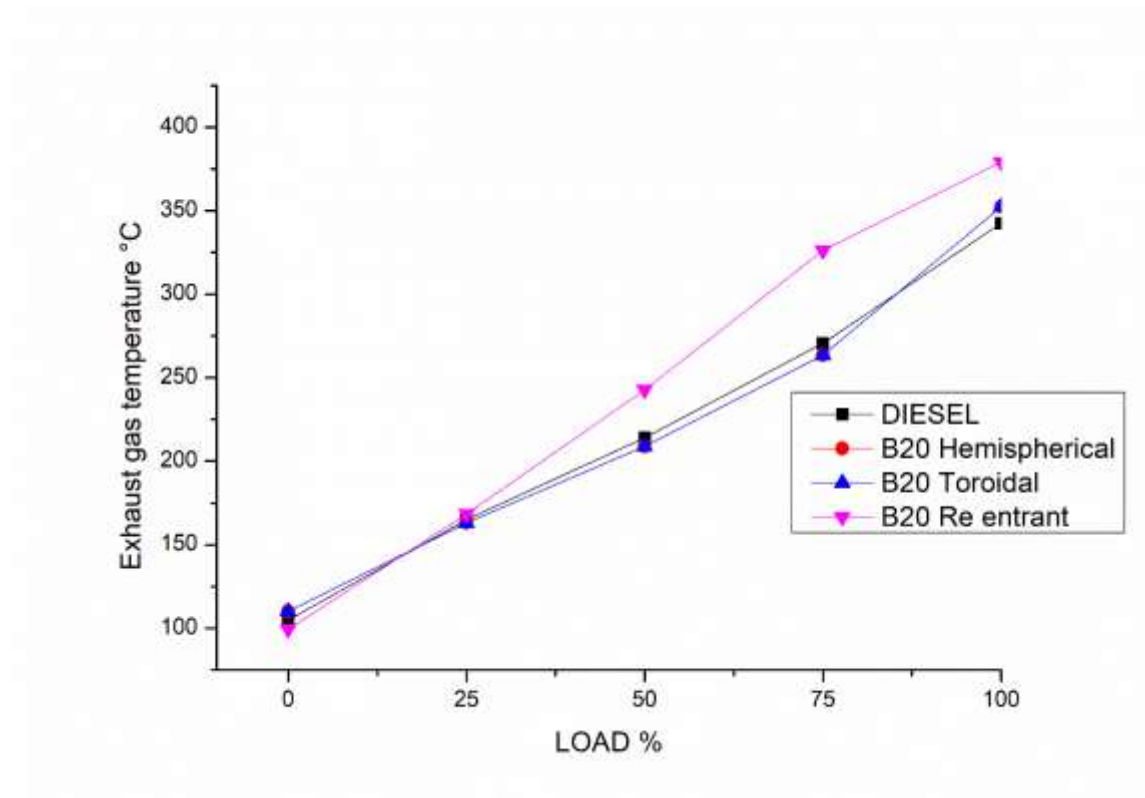


FIG: 5.4: Exhaust Gas Temperature.

5.2 EMISSION CHARACTERISTICS

Emission characteristics like CO emissions, CO₂ emissions, NO_x emissions, HC emissions and also smoke emissions results are studied and discussed in this section by drawing the graphs for all the emission levels at different loads.

5.2.1 CO Emissions

Carbon monoxide (CO) which is colorless, odorless, tasteless and toxic air pollutant which pollutes the environment. It happens due to an insufficient supply of oxygen. Inefficient mixing of the air-fuel mixture, inadequate supply of oxygen and less oxygen concentration leads to the emission of carbon monoxide.

The emission characteristic, carbon monoxide (CO emissions) results are studied and discussed from obtaining the values from engine testing and shown in the fig . The graph is drawn between the different varying loads of in-axis

and the CO emissions in the y-axis. However higher amount of biodiesel prevent to emit more CO emissions. It was found from Fig. that CO emissions rised with the increased engine load. At higher loads oxygen concentration decreases due to more amount of fuel molecules in combustion chamber. The CO emission is less in diesel compared to other B20 combustion chamber. The CO emission is higher in re entrant combustion chamber, it increased up to 1.8 % of CO emission.

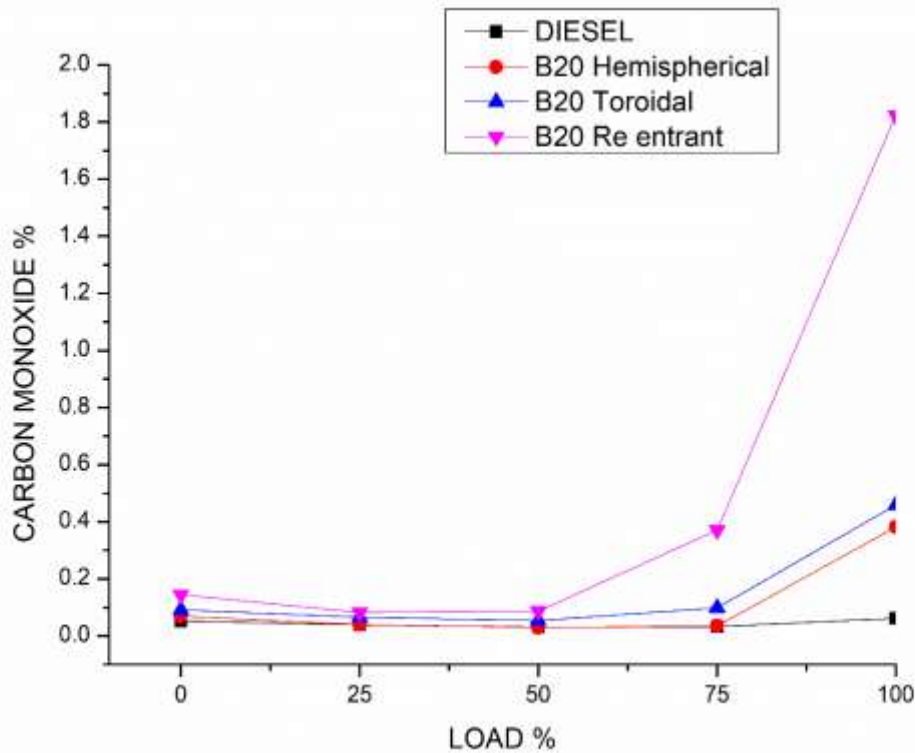


FIG: 5.5: CO Emissions.

5.2.2 Carbon Dioxide Emissions

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.

Figure 5.6 shows the emission of carbon dioxide at increasing loads. The graph shows that the carbon dioxide emission at 75% load of re entrant piston

is quite higher than the same load of normal diesel. The CO₂ emission increased with increase in engine loads. The CO₂ emission of diesel is less compared to other B20 combustion chambers. The B20 blend may increase the CO₂ emission percentage but it reduces the air toxics and cancer causing compounds. This might be due to excess heat release rate during pre-mixed phase of combustion. Secondly, in case of engine operated in dual fuel mode, the oxygen content reduces and this leads to higher CO₂ emission. (Agarwal AK, Dhar A, Srivastava DK et al 2013)

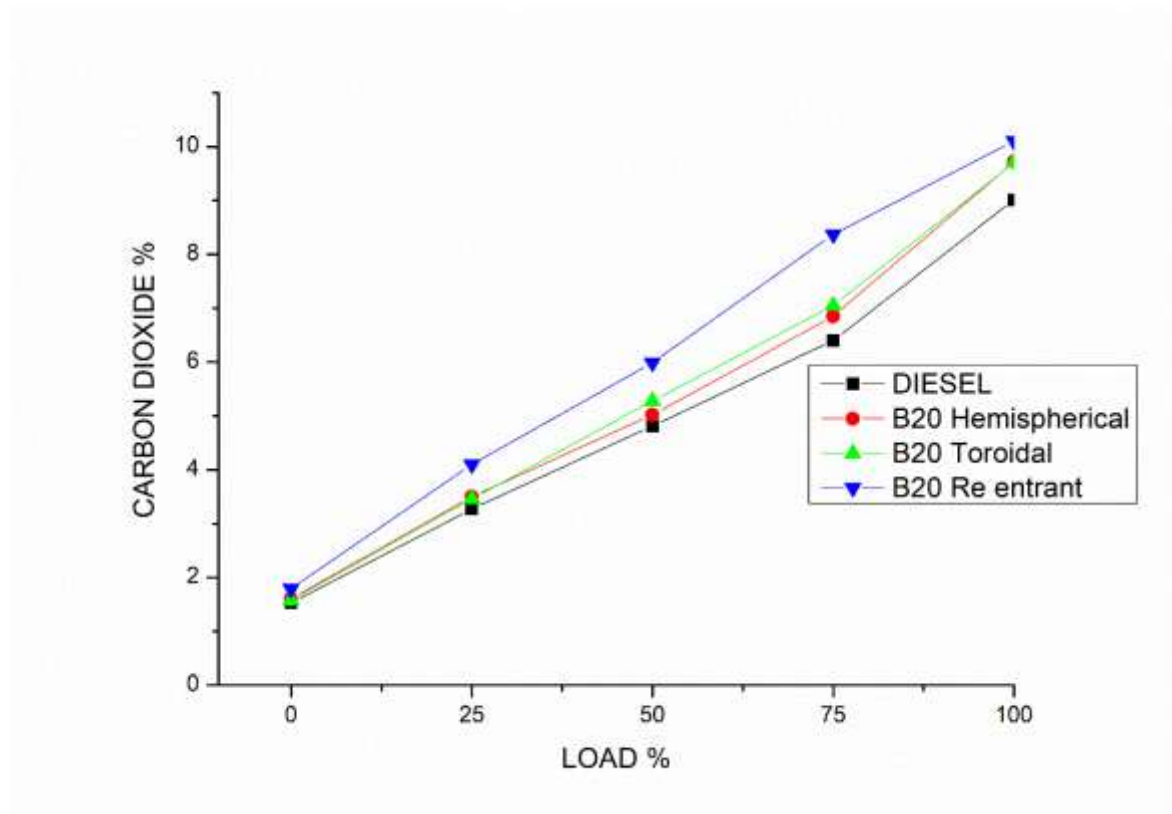


FIG: 5.6: Carbon dioxide Emissions.

5.2.3 Nitrogen Dioxide Emissions

Flame temperature and long retention time are the reasons for NO_x formation in CI engines. The biodiesel blends contain more oxygen than straight diesel. High NO_x emissions can emit when the engines air-fuel mixture is very lean. The leak in the fuel system, problem with the vehicles oxygen sensor can leads to the release of the oxides of nitrogen emissions into the atmosphere

The above graph fig shows the NO_x emission values at various loads. The graph shows that the NO_x emission at higher load of re entrant piston is quite higher than the same load of normal diesel. This might be due to slight better combustion in view of homogeneous blending and enhanced air usage attributable to improved swirl and squish motion. The NO_x emission increased with increase in engine loads. The diesel has lesser NO_x emission than all other B20 combustion chambers. (Van Gerpen, J. Biodiesel processing and production. Fuel Processing Technology 2005)

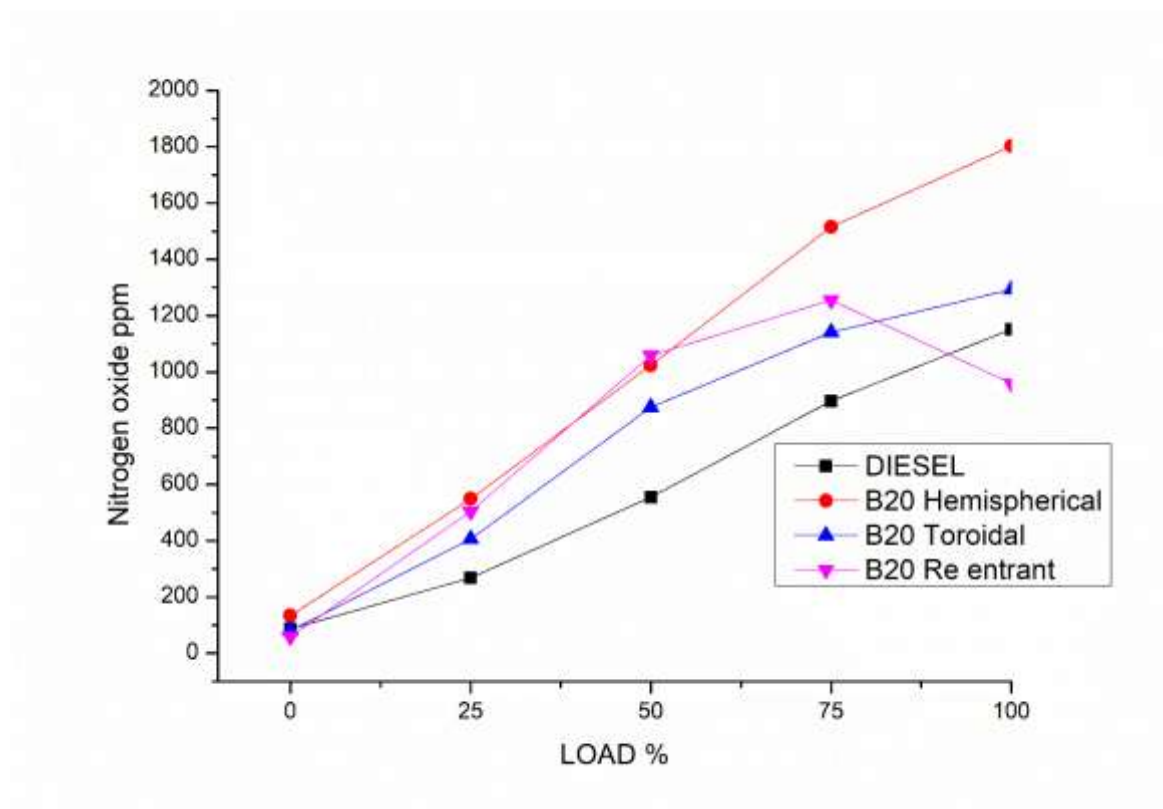


FIG: 5.7: Nitrogen dioxide Emissions.

5.2.4 Hydrocarbon Emissions

Hydrocarbon emissions are due to incomplete combustion of fuel in the combustion chamber. The poor ignition of the fuel will release the high amount of hydrocarbons into the atmosphere. The formation of the hydrocarbons is due to the very rich and lean mixtures during combustion. Over mixing of the air-fuel mixture beyond the lean flammability limits will also lead to the emission of

hydrocarbon gas to the atmosphere and this leads to the pollution in the atmosphere. the commercially available diesel or petrol diesel emits a large amount of HC when compared to the biodiesel fuel blends.

Figure shows the emission of hydrocarbons concerning the increase in loads. The results of the HC emissions obtained from the engine testing are studied and discussed in this section from the fig . The graph is drawn between the different loads in x-axis and the hc emissions in the y-axis. The graph shows that the HC emission at higher load of toroidal piston is quite higher than the same load of normal diesel. The hc emission increases with increase in engine loads. This mainly because of the insufficient amount of oxygen in the combustion chamber which results in incomplete combustion also without the presence of molecules of oxygen in combustion chamber which emits lower HC than the normal diesel. (S GHOSH et al 2012)

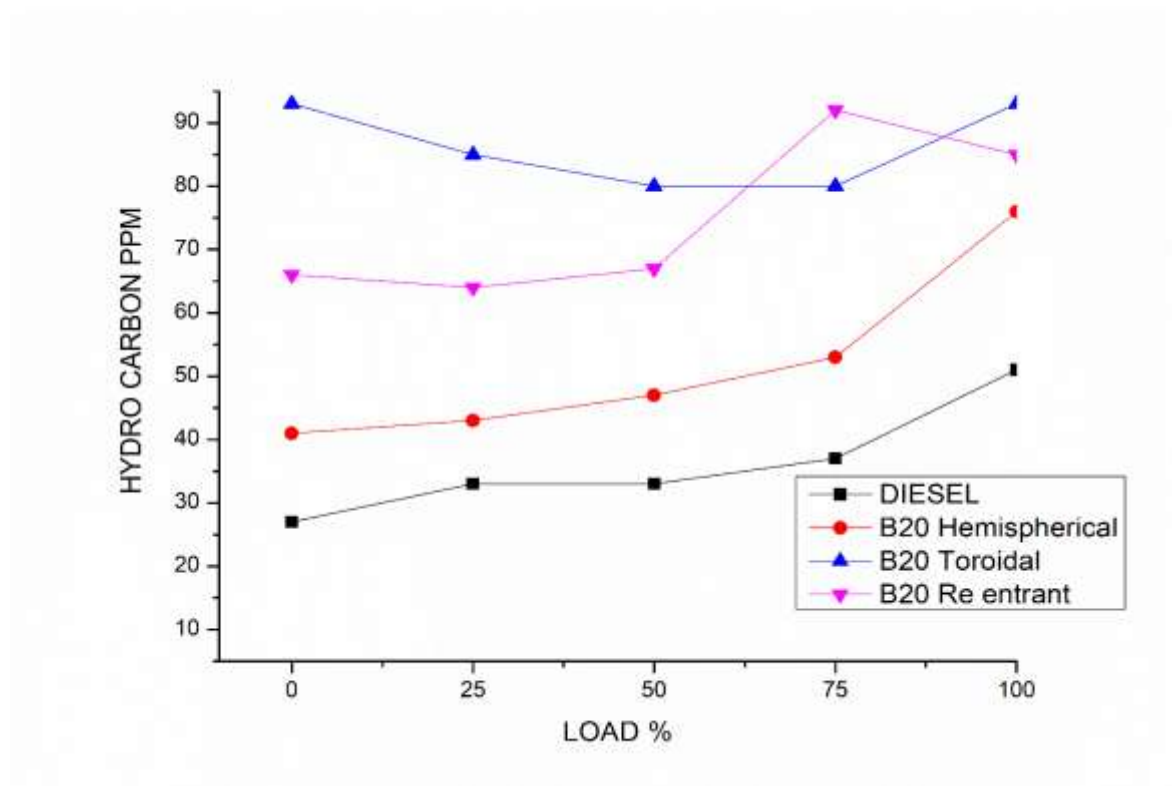


FIG: 5.8: Hydrocarbon Emissions.

5.2.5 Smoke Opacity

The type of emission particles which will produce due to the deposition of fuel on the walls of the cylinder. Opacity is the degree to which smoke block lights and helps in the measuring of the smoke which comes out from the internal combustion engine due to the fuel left on the cylinder walls. The excessive smoke will emit out if the engines are malfunctioned or maintained poorly. This emissions which comes out and went into the atmosphere will make health effects to the humans and also atmosphere

The results of the smoke opacity which is the emission parameter are studied and discussed in this section. The fig show the variation of the smoke opacity in percent against loads for the pure diesel and high performance fuel and also the blend with addition of alumina Nano additives. The graph drawn between the different loads in x-axis and smoke% in y-axis. The smoke opacity of diesel is lesser while compared with combustion chamber pistons. The smoke opacity increasing slightly with increase in loads. The smoke opacity at higher load of B20 hemispherical is higher compared to diesel in same load.

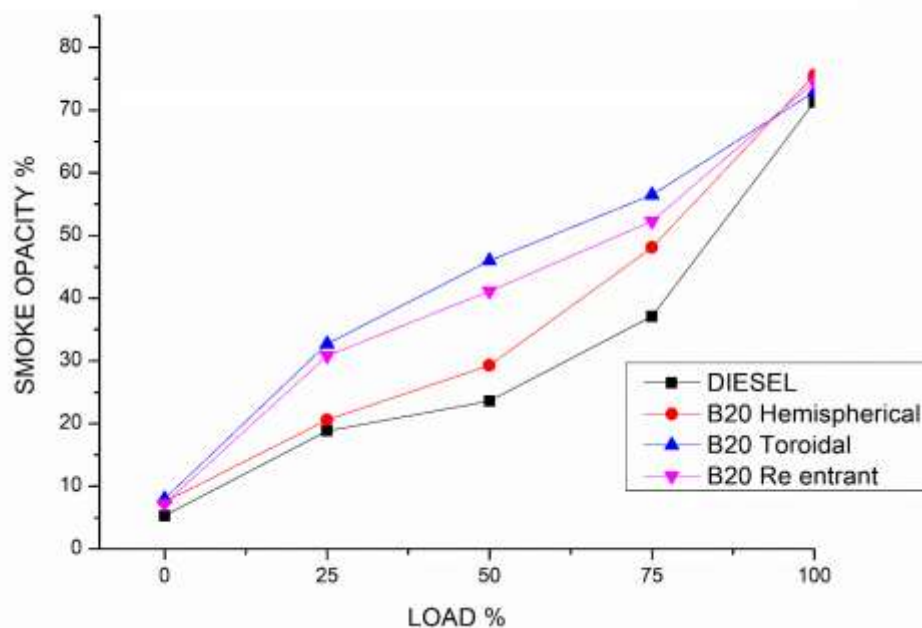


FIG 5.9: Smoke Opacity.

5.3 COMBUSTION CHARACTERISTICS :

The combustion characteristics like net heat release rate, cylindrical pressure and change in pressure due to change in heat of the blends are explained in this section and graphs are drawn and analyzed.

5.3.1 *Cylinder Pressure*

The combustion parameter which pushes the piston in the cylinder to produce power. The engine's peak cylinder pressure can be stated as the combustion of fuel and air inside the cylinder takes place, the maximum pressure developed in which the chemical energy will convert into the pressure energy. The power of the engine and also the emission levels will vary due to this cylindrical pressure.

The combustion parameter, cylinder pressure results obtained from the engine test are analyzed and discussed in the fig to fig. The graph is drawn between the crank angle in x-axis and cylinder pressure in y-axis for all different loads varying like 0%load, 25%load, 50%load, 75%load and 100%load. So totally 5 graphs are drawn for each load simultaneously. Cylindrical pressure is high for diesel and high performance fuel without adding B20 blend. The cylindrical pressure for toroidal piston chamber is lesser in all engine loads compared with other B20 combustion chambers. The re-entrant chamber is little bit higher than toroidal chamber in all the loads.

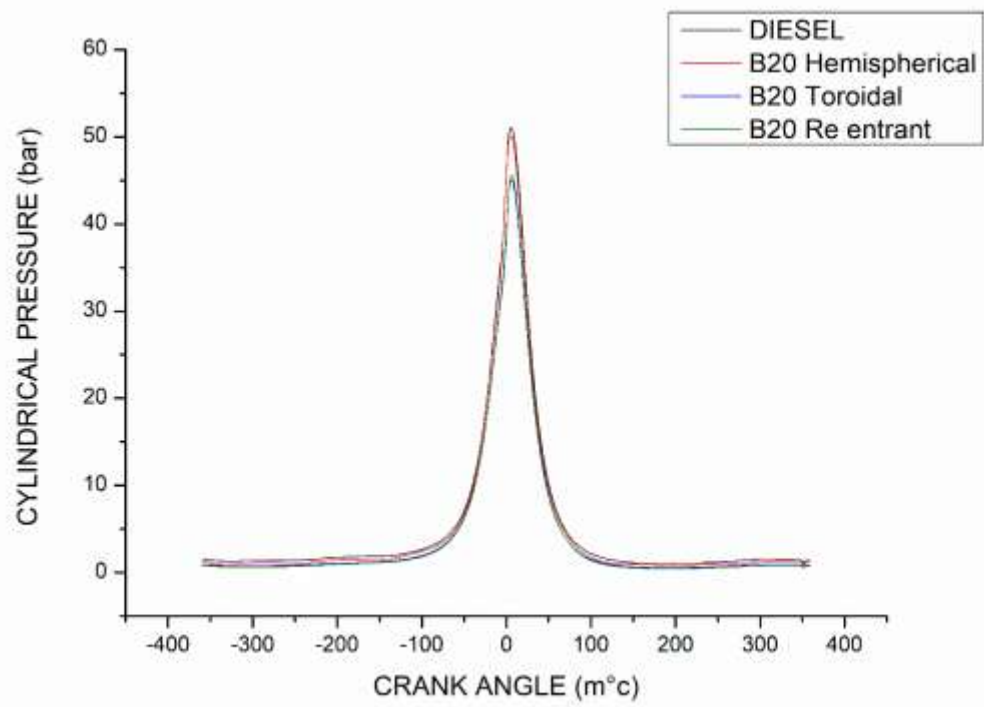


FIG: 5.10: Cylindrical Pressure at 0% Load

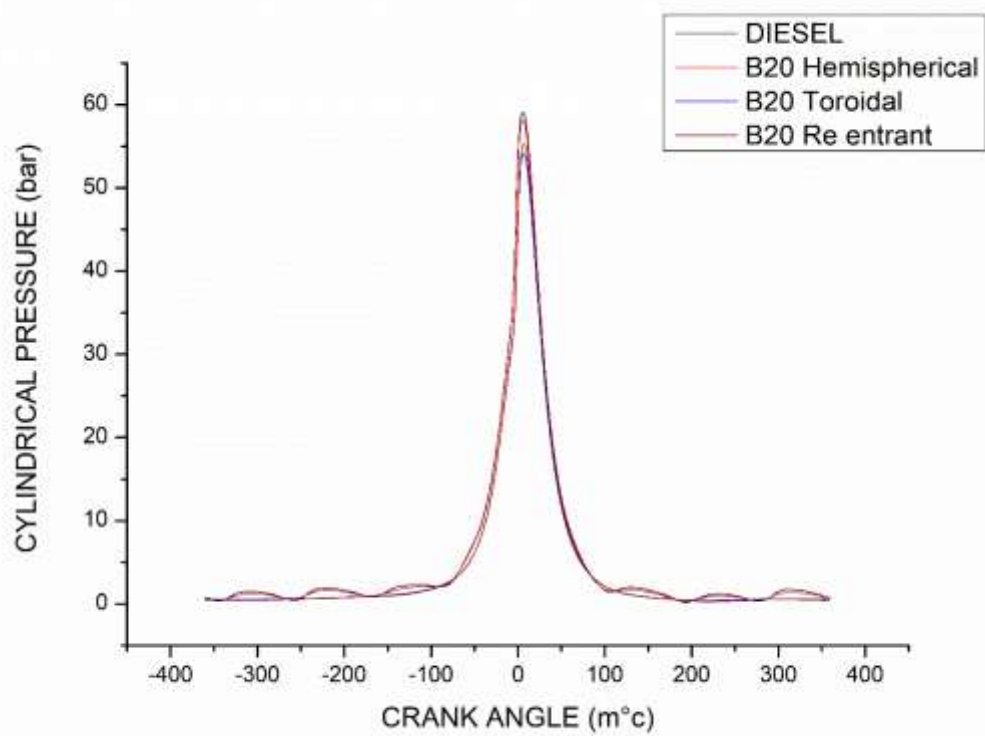


FIG: 5.11: Cylindrical Pressure at 25% Load

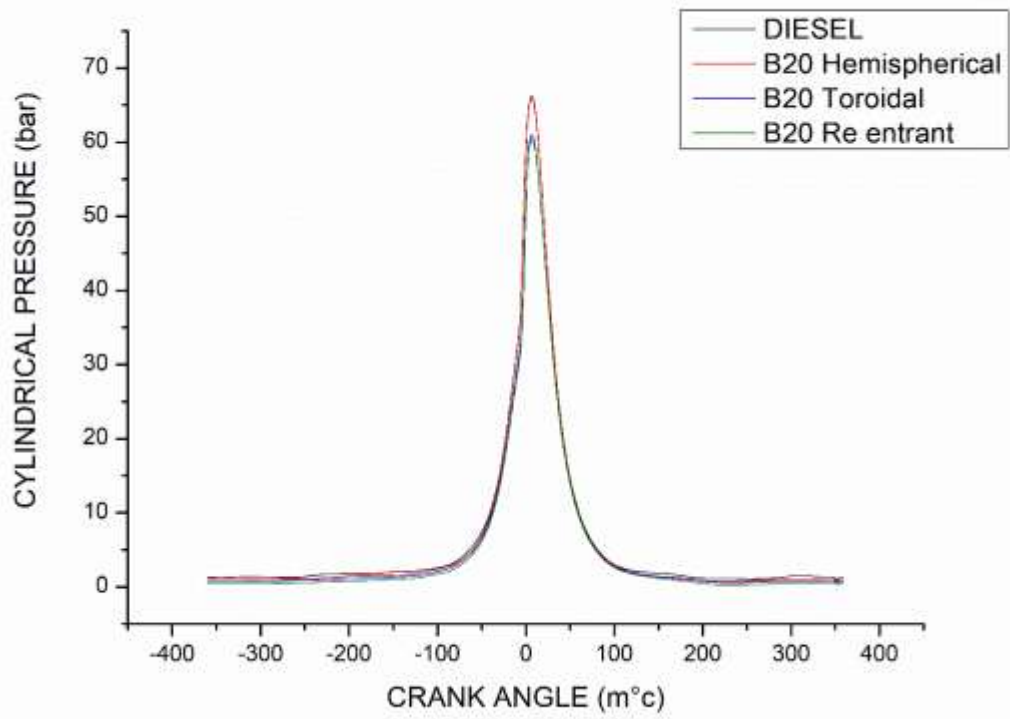


FIG: 5.12: Cylindrical Pressure at 50% Load

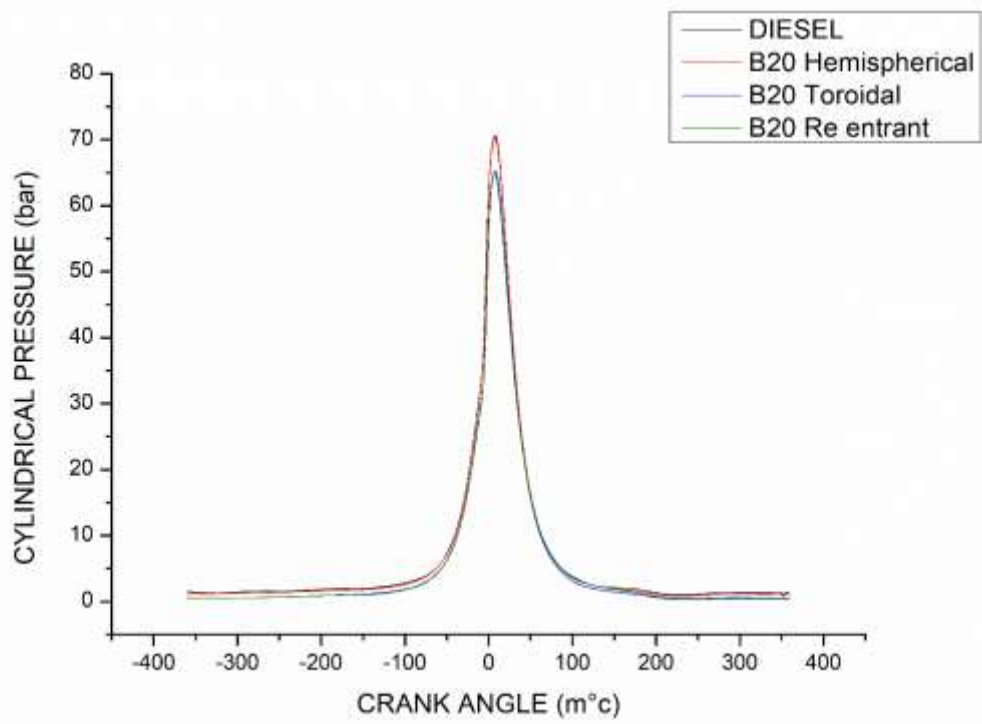


FIG: 5.13: Cylindrical Pressure at 75% Load

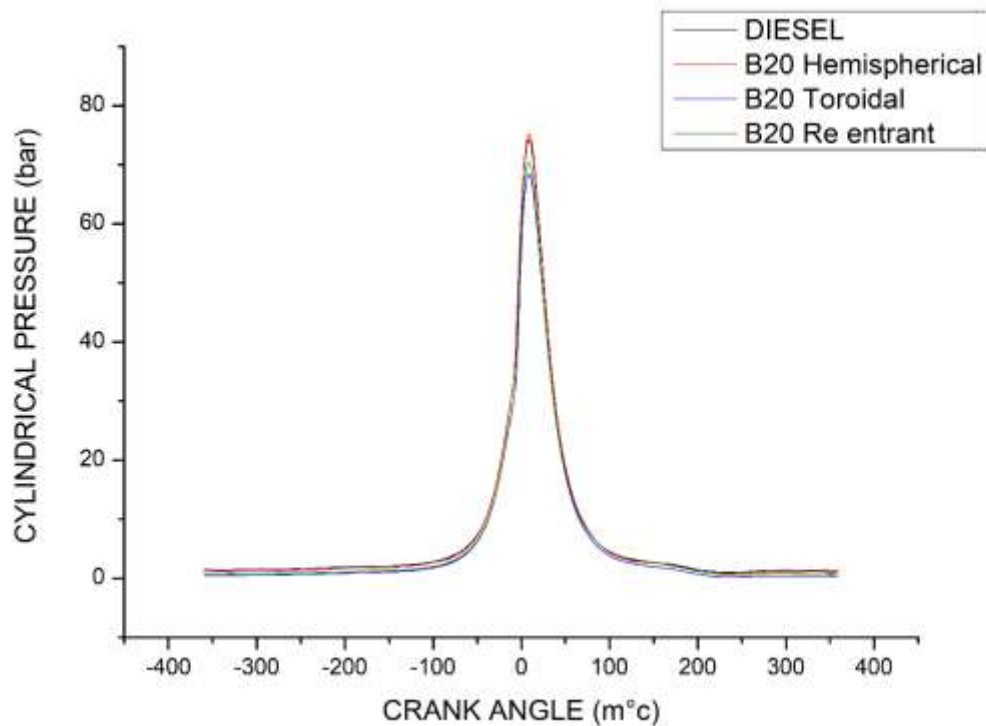


FIG: 5.14: Cylindrical Pressure at 100% Load

5.3.2 Net Heat Release Rate

In an internal combustion engines, the combustion of the fuel and air inside the cylinder of the engine takes place due to movement of the piston. The heat produced in the cylinder during this combustion is the heat release rate. The heat also can be used to improve the working medium internal energy by heating it and can be useful for doing work in the shaft. Due to the cooling water through the cylindrical walls and cylinder head some heat can be lost.

The results of the net heat release rate which is a combustion characteristic are shown in the fig to fig . The graphs drawn between the crank angle in the x-axis and heat release rate in y-axis for all the different loads like 0%load, 25% load, 50%load, 75%load and 100%load. As we analyze the graphs we get to know that the heat release rate for all the angles are almost same and are in the manner of uneven trend. As the crank angle keep on increasing the heat release rate for all the blends keep reducing in an uneven trend that if one is increasing in at one angle then it is decreasing at other load

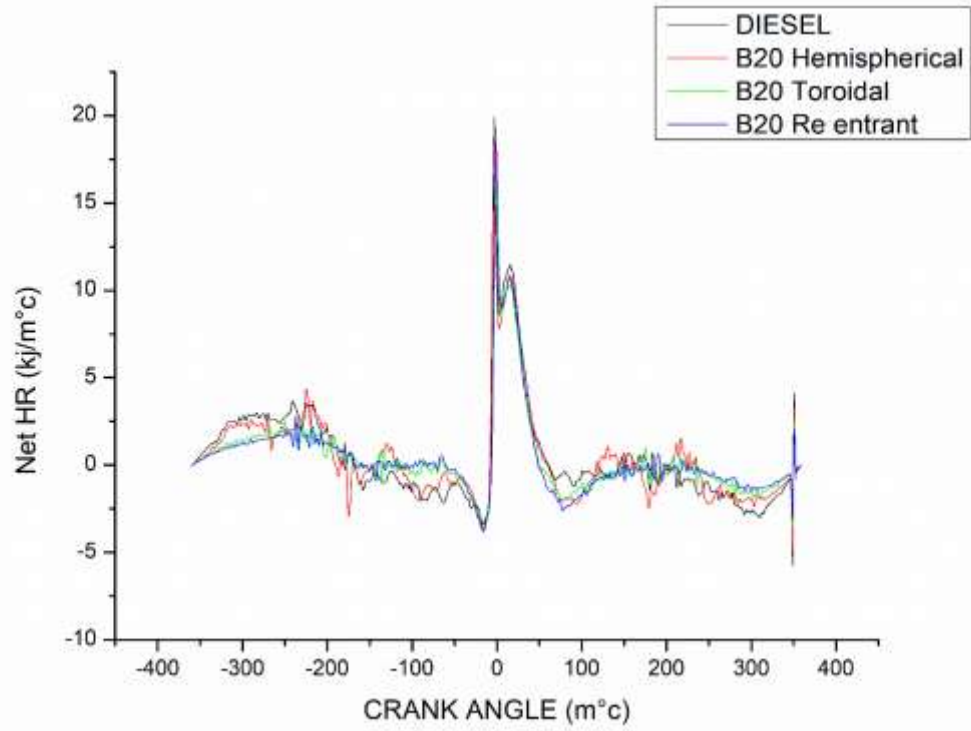


FIG: 5.15: Net heat rate at 0% Load

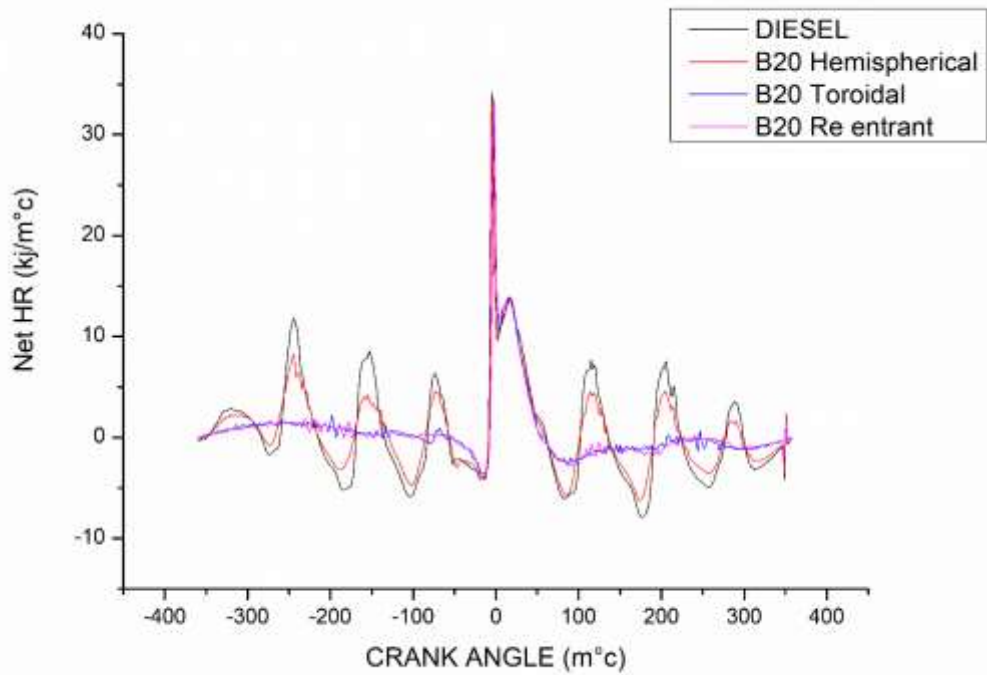


FIG: 5.16: Net heat rate at 25% Load

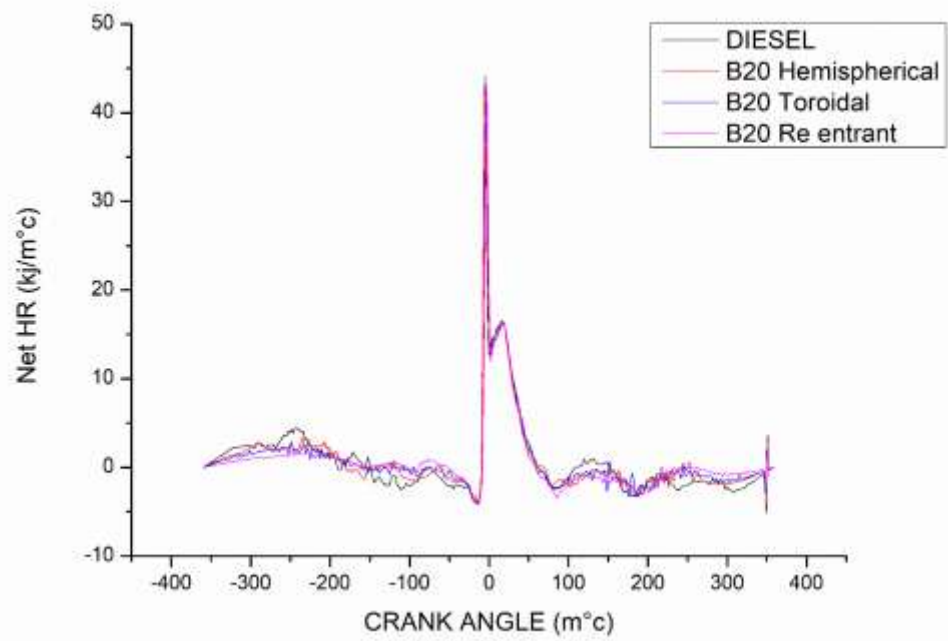


FIG: 5.18: Net heat rate at 50% Load

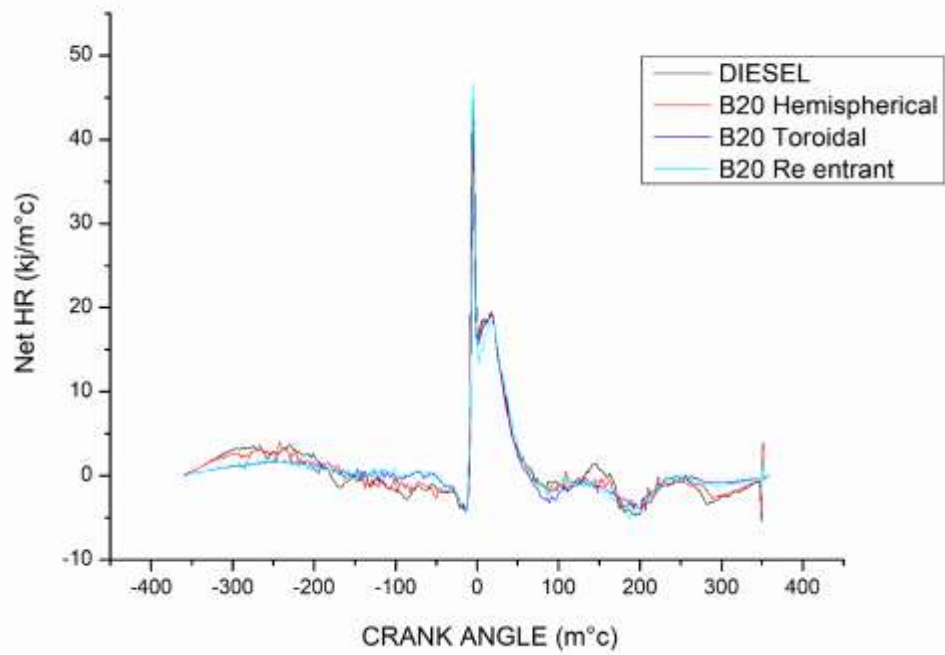


FIG: 5.17: Net heat rate at 50% Load

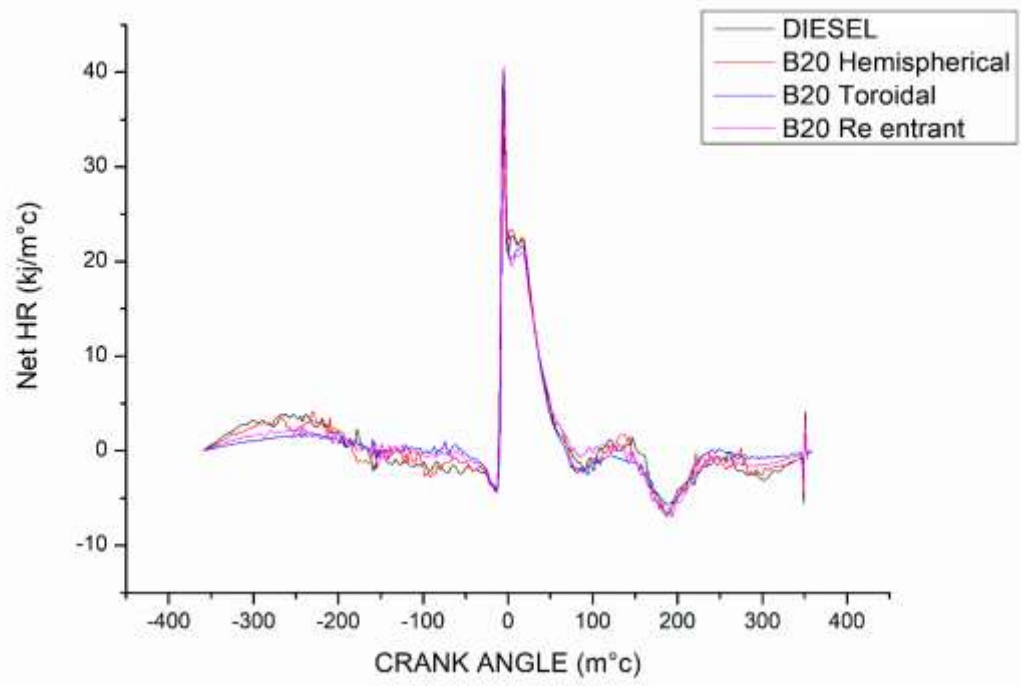


FIG: 5.19: Net heat rate at 100% Load

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 combustion chambers at different loads.
- The brake thermal efficiency is found to be very high for hemispherical combustion chamber.
- The volumetric efficiency is found to be very high for hemispherical combustion chamber and low for re entrant combustion chamber.
- NO_x emissions was lowest in case of diesel followed by hemispherical combustion chamber.
- Hydrocarbon emission was highest in case of re entrant combustion chamber.

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