

EXPERIMENTAL ANALYSIS OF BIPARTITE FUEL IN CI ENGINE

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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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **VELKUMAR M (38150123)** who carried out the project entitled **EXPERIMENTAL ANALYSIS OF BIPARTITE FUEL IN CI ENGINE** under my supervision from Nov '21 to Mar '22.

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I, **VELKUMAR M**, hereby declare that the Project Report entitled **EXPERIMENTAL ANALYSIS OF BIPARTITE FUEL IN CI ENGINE** done by me under the guidance of **Dr. J. HEMANANDH, 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.

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ABSTRACT

As the usage of non-renewable resources have become an inevitable, the search of alternate source of fuel is underway. Biodiesel, a renewable resource is a promising alternate for the current fuels. In this paper, the focus of the work is to produce Bio-oil using pork fat by implementing transesterification method and to examine the emissions when undergone combustion process with a hydrogen-air mixture in a diesel engine. The pork fat is treated with methanol and potassium hydroxide as the catalyst. The mixture is heated at a temperature of 60-70 °C. The oil obtained after letting the mixture settle was blend with diesel and tested in a diesel engine. Hydrogen is introduced into the throat of the engine and mixed with air and introduced to the blended B10 and B20 biodiesel in the combustion chamber at 3 LPM and 9 LPM. The performance of the blended biofuel and pure diesel are noted to be similar.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
1	INTRODUCTION	1
1.1	RENEWABLE RESOURCES	1
1.1.1	Solar Energy	1
1.1.2	Hydro Energy	2
1.1.3	Wind Energy	2
1.1.4	Bio-Mass	2
1.1.5	CNG	3
1.2	HYDROGEN	4
1.2.1	Hydrogen Fuel Cell	5
1.2.2	Advantages	6
1.2.3	Disadvantages	6
1.3	BIODIESEL	6
1.3.1	B20	7
1.3.2	Advantages	8
1.3.3	Disadvantages	8
2	LITERATURE SURVEY	9
3	AIM AND SCOPE	12
3.1	AIM	12
3.2	SCOPE	12
4	MATERIAL AND METHOD	13
4.1	TRANSESTERIFICATION	13
4.1.1	KOH as Catalyst	14
4.2	PROPERTIES OF OIL	15
4.3	PROPERTIES OF HYDROGEN	15
4.4	EXPERIMENTAL SETUP	16

CHAPTER No.	TITLE	PAGE No.
	4.4.1 Hydrogen Enrichment	16
4.5	ENGINE SPECIFICATION	17
4.6	TEST PROCEDURE	17
5	RESULT AND DISCUSSION	19
5.1	CARBON MONOXIDE EMISSION	19
5.2	HYDROCARBON EMISSION	20
5.3	CARBON DIOXIDE EMISSION	21
5.4	NITROGEN OXIDE EMISSION	22
5.5	BRAKE THERMAL EFFICIENCY	23
5.6	BRAKE SPECIFIC FUEL CONSUMPTION	24
5.7	HEAT RELEASE RATE	25
5.8	PRESSURE AND CRANK ANGLE	26
6	SUMMARY AND CONCLUSION	27
6.1	SUMMARY	27
6.2	CONCLUSION	27
	REFERENCE	29

LIST OF ABBREVIATIONS

ACRONYM	EXPANSION
CI	Compressed Ignition
PFO	Pork Fat Oil
FFA	Free Fatty Acid
LPM	Liter per minute
BTE	Brake Thermal Efficiency
BP	Brake power
SFC	Specific fuel consumption
D.I.	Direct Injection
psi	Pounds per Square Inch
RPM	Rotations per minute
ppm	Parts per million
cc	Cubic centimeters
B10	10 % bio diesel 90 % Diesel
B20	20 % bio diesel 80 % Diesel
CO	Carbon monoxide
HC	Hydrocarbon
CO ₂	Carbon dioxide
NO _x	Nitrogen Oxides
O ₂	Oxygen

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
4.1	Pork Fat Oil	13
4.2	B10 Blend	13
4.3	B20 Blend	14
4.4	Experimental Setup	16
4.5	AVL smoke meter	17
4.6	Flow meter	17
5.1	CO emission with respect to load	19
5.2	HC emission with respect to load	20
5.3	CO ₂ emission with respect to load	21
5.4	NOx emission with respect to load	22
5.5	Brake Thermal Efficiency	23
5.6	Brake Specific Fuel Consumption	24
5.7	Heat Release Rate	25
5.8	Pressure variation with respect to crank angle	26

LIST OF TABLES

TABLE No.	TTITLE	PAGE No.
4.1	Comparative analysis of biodiesel and pure diesel	15
4.2	Basic Hydrogen properties	15

CHAPTER 1

INTRODUCTION

With the increase in the use of non-renewable resource, the need for an alternate source of renewable resource is necessary for the future. We have been using non-renewable resources for many years now and we are on the verge of running out of a source of energy. This brings forth the need to find an alternative source of energy for our daily life and more importantly for the development of future generation.

1.1 RENEWABLE RESOURCES

Renewable energy is generated by sources which will be replenished within a comparatively short period of your time. Solar, wind, water, biomass, and geothermal are all renewable energy sources. Green energy, while almost like renewable energy, may be a subset of sources that have the very best environmental benefits. Clean energy sources emit low carbon and include renewable energy sources alongside atomic power.

Renewable energy sources are wont to generate heat and power for much of human history, and more relatively recently, electricity. Renewable energy makes up 12% of primary energy use within the us and 11% worldwide. While there's still a robust dependence on fossil fuels for heating, electricity and transportation, the oil crises of the 1970s pushed for stronger investment into energy sources. Additionally, the negative effects of global climate change have increased public demand find non-fossil fuel-based energy, aided by government incentives and standards.

1.1.1 Solar Cells

When light shines on a photovoltaic (PV) cell also called a photovoltaic cell that light could also be reflected, absorbed, or pass throughout the cell. The PV cell consists of semiconductor material; the “semi” means it can conduct electricity better than an insulator but not also as an honest conductor sort of a metal. There are several different semiconductor materials utilized in PV cells. When the

semiconductor is exposed to light, it absorbs the light's energy and transfers it to charged particles within the material called electrons. This extra energy allows the electrons to flow through the fabric as an electrical current. This current is extracted through conductive metal contacts the grid-like lines on a photovoltaic cell and may then be used to power your home and therefore the remainder of the electrical grid.

1.1.2 Hydro Energy

Hydroelectric energy, also called hydroelectric power or hydroelectricity, may be a sort of energy that harnesses the facility of water in motion—such as water flowing over a waterfall—to generate electricity. People have used this force for millennia. Over two thousand years ago, people in Greece used flowing water to turn the wheel of their mill to ground wheat into flour. Most hydroelectric power plants have a reservoir of water, a gate or valve to regulate what proportion water flows out of the reservoir, and an outlet or place where the water finishes up after flowing downward. Water gains P.E. just before it spills over the highest of a dam or flows down a hill. The P.E. is converted into K.E. as water flows downhill. The water is often used to turn the blades of a turbine to get electricity, which is distributed to the facility plant.

1.1.3 Wind Energy

Wind power is that the process of harnessing energy from the movement of the wind and converting it to useful sorts of mechanical power and electricity. Today, most wind energy comes from turbines - essentially giant windmills. The wind turns two or three of the turbine's propeller-like blades round the turbine's rotor. The rotor is connected to a main shaft, which spins a generator to make electricity. The technological development of recent years, bringing more efficient and more reliable wind turbines, is making wind generation less expensive. generally, the precise energy costs per annual kWh decrease with the dimensions of the turbine not withstanding existing supply difficulties.

1.1.4 Biomass

Biomass may be a complex natural renewable material with enormous chemical variability. Its potential for energy production varies in reference to the method

used, which can involve elementary or highly sophisticated technologies. Since this material are often found altogether continents, its use for energy production and secondary energy products (solid, liquid, and gaseous fuels) should be promoted and therefore the recovery capacities of agricultural, forestry, and industrial residues increased. alongside other renewable resources, like solar, wind, and hydroelectric, biomass may be a major future sustainable energy resource of the earth .

Biomass has been used as a fuel source ever since humanity learned to form fire and served because the primary source of energy before fossil fuels became common within the twentieth century. Biomass remains the dominant source of energy for one billion of the poorest people. Biofuels are attractive for variety of reasons - plants act as 'solar panels', capture carbon, and store energy. Their large-scale adaptation as energy source for contemporary industrial societies hinges on the solar utilization efficiency of plants. Plants appear to possess similar efficiencies in capturing radiation because the most effective solar panels which will be deployed at large scale, but the plants' own metabolism combined with the 'metabolism' of the infrastructure to supply biofuel from biomass yields a really low solar utilization. The climate vulnerability of biomass as renewable energy source is essentially almost like food crops. Slight differences could be expected for various biofuel types.

1.1.5 CNG

Unlike gasoline or diesel stations, compressed gas (CNG) stations aren't "one size fits all." Building a CNG station for a retail application or a fleet requires calculating the proper combination of pressure and storage needed for the kinds of vehicles being fueled. Making the proper choices about the dimensions of the compressor and therefore the amount of storage at the station will impact the value of fuel and range for vehicles.

There are two sorts of CNG infrastructure: time-fill and fast-fill. the most structural differences between the 2 systems are the quantity of storage capacity available and therefore the size of the compressor. These factors determine the quantity of fuel dispensed and therefore the time it takes for CNG to be delivered.

Fast-fill: Generally, fast-fill stations are best fitted to retail situations where vehicles arrive randomly and wish to refill quickly. All public CNG stations have a fast-fill option. Fast-fill stations receive fuel from an area utility line at a coffee pressure then use a compressor on site to compress the gas to a high. Once compressed, the CNG moves to a series of storage vessels, therefore the fuel is out there for a fast fill-up. CNG also can be delivered via dispensers alongside gasoline or other fuel dispensers. CNG at fast-fill stations is usually stored within the vessels at a high service pressure (4,300 psi) therefore the dispenser can deliver it to a vehicle quickly. The dispenser uses sensors to calculate pressure and measure the amount of gasoline gallon equivalents delivered to the tank, taking temperature under consideration.

Time-fill: Time-fill stations are used primarily by fleets and work best for vehicles with large tanks that refuel at a central location nightly. At a time-fill station, a gas line from a utility delivers CNG at a coffee pressure to a compressor on site. Unlike fast-fill stations, vehicles at time-fill stations are generally filled directly from the compressor, not from fuel stored in high vessels. the dimensions of the compressor needed depends on the dimensions of the fleet. Although there's a little buffer tank, its purpose isn't to fill vehicles but to stay the compressor from cycling off and on unnecessarily wasting electricity and causing undue wear and tear on the compressor. The tank is usually wont to refill vehicle tanks during the day.

1.2 HYDROGEN

Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind. These qualities make it an attractive fuel option for transportation and electricity generation applications. It can be used in cars, in houses, for portable power, and in many more applications. Hydrogen is an energy carrier that can be used to store, move, and deliver energy produced from other sources. Today, hydrogen fuel can be produced through several methods. The most common methods today are natural gas reforming (a thermal process), and electrolysis. Other methods include solar-driven and biological processes.

Among the four zero-emissions technologies, hydrogen combustion is still in its infancy, despite a (patchy) history going back to the 1806 de Rivaz engine, which ran on a hydrogen-oxygen mixture. For a long time, hydrogen combustion engines were disregarded, as the very high costs of hydrogen made the powertrain uneconomical. Today, however, some automotive OEMs, component suppliers, and start-ups are reconsidering hydrogen combustion as an additional component of their future powertrain portfolios, alongside batteries and fuel cells.

USES

- Hydrogenation of fats and oils
- Rocket fuel
- Welding
- Production of hydrochloric acid
- Reduction of metallic ores

1.2.1 Hydrogen Fuel cell

Hydrogen fuel cells provide a promising alternative to combustion engines due to their clean exhaust emissions, higher efficiencies, and renewable fuel sources. For hydrogen cell vehicles to realize widespread consumer acceptance several technical challenges got to be addressed, one such challenge is that the removal of waste heat in mobile applications. A recent study into operating cell vehicles showed the thermal management subsystem to be the most explanation for unscheduled vehicle maintenance with 39% of events attributed to the present subsystem compared to 10% for the cell stack.

Hydrogen fuel cells are one among the foremost promising alternatives to combustion engine hybrids and pure battery electrical power for propelling passenger vehicles. Compared to combustion engine hybrid vehicles burning hydrocarbon fuels, cell vehicles offer three primary advantages. First, the cell system produces no tank-to-wheel CO₂ emissions and no other harmful emissions like oxides of nitrogen, carbon monoxide gas, or particulates. Second,

the cell system offers the potential for about 30% higher well-to-wheel energy efficiency. Third, the hydrogen fuel consumed by the cell are often produced from a spread of renewable sources including carbon-free methods like electrolysis of water. A cell vehicle is often refilled with compressed hydrogen at a rate of 2.0 kg hydrogen per minute. To recharge a battery electric vehicle at the same rate would require the battery and charger to handle 2.5 MW of power. Such a charger would be 400 times larger than that typically used for battery electric vehicles.

1.2.2 Advantages

- Renewable and readily available
- Powerful and energy efficient than fossil fuels
- Almost zero emissions
- Reduces carbon footprints
- Long usage times
- Very low density

1.2.3 Disadvantages

- Hydrogen Extraction
- Investment is Required
- Hydrogen Storage
- Highly Flammable

1.3 BIODIESEL

Biodiesel is one among the simplest sorts of natural resource which will be used as an alternate means of fuel which produce less harmful gases. Bio diesel is a method to scale back the main damage caused to the ozone by humans. the utilization of natural resource will promise a far better future for the upcoming generation. Biodiesels are often obtained from different sources through different process. Bio diesel is usually not used as fuel for transportation in its pure form (B100). Biodiesel refers to an oil - or animal fat-based diesel oil consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is usually made by chemically reacting lipids [e.g., vegetable oil, fat (tallow)] with an alcohol. Biodiesel is supposed to be utilized in standard diesel engines and is thus distinct from the vegetable and waste oils want to fuel converted diesel engines.

Biodiesels are often used alone or blended with Petro-diesel. Biodiesel also can be used as a carbon alternative to fuel oil.

The use of biodiesel in conventional diesel engines leads to substantial reduction of unburnt hydrocarbons, carbon monoxide gas and particulate matters. Biodiesel is considered clean fuel since it's almost no Sulphur, no aromatics and has about 10 per cent built-in oxygen, which helps it to burn fully. Its higher cetane number improves the ignition quality even when blended within the petroleum diesel.

Biodiesel is produced locally. A locally produced fuel is going to be more cost-efficient. There's no need to pay tariffs or similar taxes to the countries from which the oil and petroleum diesel are sourced. Every country has the power to supply biodiesel. Biodiesels are often utilized in diesel engines. It is often also blended with Petro-diesel and utilized in standard diesel engines in any percentage i.e., 1% of pure biodiesel blended with 99% of Petro-diesel. Biodiesel has lower toxicity compared to standard diesel. It degrades faster than diesel oil which significantly helps in reducing the environmental consequences of bio-fuel spills.

A blended biodiesel fuel might be utilized in most traditional diesel engines. B20 and B10 are federally regulated fuels. There are about 1,000 filling stations, mostly within the Midwest, that provide this blended fuel. Biodiesel blends also can be specially ordered if you reside in a neighborhood that does not have a B10 or B20 gasoline station. Blended biodiesel fuel has the advantage of having the ability to run in any quite diesel with no modifications necessary.

1.3.1 B20 Blend

B20 may be a common blend because it represents an honest balance of cost, emissions, cold-weather performance, materials compatibility, and skill to act as a solvent. Most biodiesel users purchase B20 or lower blends from their normal fuel distributors or from biodiesel marketers. Engines operating on B20 have similar fuel consumption, horsepower, and torque to engines running on petroleum diesel. B20 with 20% biodiesel content will have 1% to twenty less energy per gallon than petroleum diesel, but many B20 users report no noticeable difference in

performance or fuel economy. Biodiesel also has some emissions benefits, especially for engines manufactured before 2010. For engines equipped with selective catalytic reduction (SCR) systems, the air quality benefits are an equivalent whether running on biodiesel or petroleum diesel.

1.3.2 Advantages

- Produced From Renewable Resources
- Can be Used in Existing Diesel Engines
- Less Greenhouse Gas Emissions
- Grown, Produced and Distributed Locally
- Cleaner Biofuel Refineries
- Biodegradable and Non-Toxic
- Better Fuel Economy
- Reduced Foreign Oil Dependence

1.3.3 Disadvantages

- Variation in Quality of Biodiesel
- Not Suitable for Use in Low Temperatures
- Biodiesel Could Harm the Rubber Houses of Some Engines
- Increased use of Fertilizers
- Clogging in Engine
- Regional Suitability
- Fuel Distribution

CHAPTER 2

LITERATURE SURVEY

Ashish Kumar Singh et al., (2021) [1], experimented on a single cylinder CI engine using WAF biodiesel blends and the performance of the engine at high pressure is derived. Emission of NO_x is observed to be higher.

Aditya Johari et al., (2022) [2] and Antonio Caricato et al., (2021) [3], performed a study on how late pilot injection in dualfuel diesel/ natural gas combustion affect the performance of the engine and observed that 10% hydrogen addition to the natural gas can improve the performance.

Carlos Tealdo et al., (2020) [4], experimented in a direct injection diesel engine by adding hydrogen to the inlet manifold and observed that the result of the added hydrogen test showed improved performance with marginal increase in emission.

C. J. Ramsay et al., (2020) [5], investigated the performance of a diesel-hydrogen dual fuel injection in constant volume combustion phase. The difference in the emission of through CVCP and normal method is explained.

Dinçer Akal, Semiha Öztuna et al., (2020) [6] experimented and explained the effects of adding hydrogen in gasoline, LPG and diesel engines. It has been mentioned that the emission results vary in LPG and gasoline engine based on the amount of hydrogen supplied.

Gokul Raghavendra Srinivasan et al., (2020) [7], conducted a study on the process optimization and characteristic assessment of waste animal fat (WAF) biodiesel based on the influence of fatty acids characterized in it and observed slight reduction in engine performance was due to high viscosity and reduced calorific value of biodiesel.

G. Antony Casmir Jayaseelan et al., (2021) [8], noticed that the Brake Thermal Efficiency is increased with increase in injection pressure with the emission parameters such as carbon monoxide (CO), Hydrocarbons (HC) so that smoke capacity reduces for B40.

Héctor de Paz Carmona et al., (2021) [10], explained the necessary implementation of cleaning step in the process of obtaining animal fat biofuel before co-processing with medium distillates to produce advanced biofuels.

İlker Temizer et al., (2020) [11], experimented combustion characteristics and emission of diesel engine with standard combustion chamber and modified combustion chamber. They observed the use of hydrogen as additional fuel resulted in higher combustion pressure, temperature and NO emissions.

Javad Zareei et al., (2021) [12], conducted an experiment on the effect of hydrogen addition in diesel in a three-cylinder four stroke engine and the experimental results showed an increase in cylinder pressure by 9%.

J.M.Encinar et al., (2021) [13], conducted an experimental study on converting high acidity animal fats to biodiesel through two step transesterification. The influence of catalyst concentration, methanol/fat ratio and reaction time corresponding to transesterification is studied.

MbalonDiaye et al., (2020) [15], experimented with a crude fat refining process composed of vacuum distillation step and a glycolysis step to convert the free fatty acids recovered from distillation step into triglycerides.

Pali Rosha et al., (2022) [18], conducted an experimental study on the effect of compression ratio on hydrogen enriched biodiesel emission and explained higher compression ratio improves performance.

R. Z. Kavtaradze et al., (2021) [19], experimented on using lean fuel mixture in a hydrogen engine and observed reduce in NO_x emission, heat loads and improved the heat stressed state of the piston.

Salman Abdu Ahmed et al., (2020) [20] and Shyamal Das et al., [21] (2022) explained how addition of hydrogen in biogas resulted in a rise in heat release rate (HRR), Ignition delay improve, and combustion duration drops.

Surya Kanth et al., (2020) [22], explained the difference in the emission results of a normal biodiesel engine and a hydrogen enriched biodiesel blend. It has been observed that the hydrogen enrichment increases the in-cylinder pressure and net heat release rate.

Shengbo Ge et al., (2021) [23], experimented with chicken fat to produce biodiesel through transesterification with eggshell as a dominated catalyst. The performance results of the experiment showed increased brake power, BTE, EGT and HRR while reduced the CO, HC and smoke emissions.

S. Jaikumar et al., (2021) [24], conducted an experimental study using hydrogen and Niger seed oil methyl ester blends in a diesel engine and observed the performance, combustion, emission of the engine.

U. S. Jyothi and K. Vijaya Kumar Reddy (2020) [26], performed an experimental study on the particle diameter in hydrogen enriched diesel engine by using different combustion bowl geometrics. The effects of different particle diameter are explained through various tests.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of the project is to obtain Biodiesel from Pork fat through transesterification process and test the obtained oil in different blends with Hydrogen in a CI engine to get emission and performance results

3.2 SCOPE

The objective of the experiment includes,

- Effective way to obtain Biofuel from pork fat through transesterification.
- Improve the performance of the engine with the addition of Hydrogen in the combustion process.
- To test the biofuel in the engine and the emissions of HC, CO, CO₂ and NO_x are noted.

CHAPTER 4

MATERIALS AND METHODS

Pork fat is obtained from the local meat shop and Transesterification process is used to obtain the biodiesel. Potassium Hydroxide is used as the catalyst in this process.

4.1 TRANSESTERIFICATION

In the Transesterification process a glyceride reacts with alcohol (methanol) in the presence of a catalyst forming fatty alkyl esters and alcohol. The process is a reversible reaction and carried out by mixing the reactants- fatty acids, alcohol, and catalyst. Pork fat has large amount of Free Fatty Acid (FAA). The pork fat goes through two step transesterifications to lower the amount Free Fatty Acids. A strong base is used as a catalyst. Potassium hydroxide is used as it dissolves better with methanol. The pork fat is treated with methanol and potassium hydroxide as the catalyst. The mixture is heated at a temperature around 60-70°C. The obtained oil was allowed to settle for some time and glycerine was allowed to settle in the bottom layer. The methyl ester at the upper layer is separated. The obtained biodiesel is blended with diesel in two proportion, B10 (a blend of 10% Biodiesel and 90% diesel) and B20 (a blend of 20% and 80% diesel) as shown in Fig. 4.2 and 4.3. The table 4.1 shows the comparative analysis of the obtained biodiesel and pure diesel.



Fig.4.1 Pork Fat



Fig.4.2 B10 Blend



Fig.4.3 B20 Blend

4.1.1 KOH as catalyst

KOH dissolves a touch easier in methanol than NaOH. Although not everyone notices the difference, most do. Under certain conditions NaOH will make glycerin by-product that turns to a gel or maybe solid. Not a drag after the glycerin has been drained, but an enormous problem if it's still in your processor or plumbing and goes solid.

KOH is more forgiving on high titration oils than NaOH. High titration oils make tons of soap. If we use NaOH and there's enough soap, you get a tank filled with gelatinous goo that contains mostly soap. KOH on the opposite hand being liquid doesn't seem to interfere with the reaction. The result's that we will process much higher titration oils with KOH than we will with NaOH.

KOH may be a heavier molecule than NaOH and since we weigh our catalyst, we use more KOH than we use of NaOH. Mathematically we use 1.4 times the maximum amount KOH as NaOH. When making biodiesel we use a base of 5 grams per liter for NaOH and seven grams per liter of KOH. to the present we add our titration values. While NaOH is comparatively pure, KOH is typically only available with about 90% purity. this needs us divide the 7 grams by .9 to regulate our base up to 7.7 grams per liter.

4.2 PROPERTIES OF THE OIL

Table 4.1 Comparative analysis of biodiesel and pure diesel

S. No	Parameters	Biodiesel	Pure diesel	ASTM Standards of pure diesel
1	Density	880 Kg/m ³	830 Kg/m ³	
2	Kinematic Viscosity @ 40°C	1.28 mm ² /s	2.5 mm ² /s	1.9 - 4.1 mm ² /s
3	Flash point by PMCC method	61°C	52°C	52°C
4	Fire point by PMCC method	70°C	60°C	
9	Calorific value	33000 kJ/kg	42000 kJ/kg	

4.3 PROPERTIES OF HYDROGEN

Table 4.2 Basic Hydrogen properties

Atomic mass	1.007825 g/mol
Density	0.083 kg/m ³
Boiling point	294 °C
Calorific Value	150000kJ/kg
Density	0.08375 Kg/m ³
Specific gravity	0.0696

Hydrogen gas has a very low viscosity as shown in table 4.2. This should be considered when a gas device is tested for leaks. A device that is tight against air may not be against hydrogen. If there is a leak, then the rate of volumetric flow of hydrogen gas through the same cross-section will be greater than that of natural gas or air. This safety hazard is somewhat balanced by the fact that hydrogen gas has a rather low volumetric energy density so that a higher volume of released gas does not necessarily constitute a greater risk of explosion.

4.4 EXPERIMENTAL SETUP



Fig 4.4 Experimental setup

The experimental test is one on a single cylinder, four stroke, Diesel engine as shown in Fig 4.4 which is connected to eddy current type dynamometer for loading. The dynamometer is used to provide different brake loads and the performance for each respective loads are measured by the engine test setup. The Emission of CO (% volume), HC (ppm), NO_x (ppm) and CO₂(ppm) are measured using an AVL 444 di gas analyser shown in Fig 4.5. The AVL 437C free accelerator smoke meter was used to measure the density of the smoke in Hatridge smoke units.

4.4.1 Hydrogen enrichment

Hydrogen can be injected in a diesel in different methods like direct injection, manifold injection, Continuous manifold injection. In this test, Hydrogen is injected in the throat.

Direct injection is where hydrogen is directly injected in the combustion chamber, but it requires major design changes in engine. Instead of using hydrogen as a standalone fuel, it is used as addition to blended biodiesel in this experiment. For volumetric efficiency, hydrogen is mixed with air during intake and introduced to the biodiesel as a hydrogen-air mixture. Since hydrogen has high flammability and higher combustion rate, the addition of hydrogen with biodiesel shows better performance.

This could also decrease the emission since hydrogen does not have any carbon in it and when used alone hydrogen almost gives zero emission.



Fig 4.5 AVL Smoke meter



Fig 4.6 Flow meter

4.5 ENGINE SPECIFICATION

Engine Type	-Four stroke, Single Cylinder Vertical Water-Cooled Diesel Engine
Power	-5.2 kW
Speed	-1500 rpm
Bore Diameter	-87.5mm
Stroke Length	-110mm
Compression ratio	-17.5:1

4.6 TEST PROCEDURE

The engine was checked for any fuel leakage and lubrication oil is checked. The engine is first run with pure diesel with different loads. The load is applied to the engine using electrical dynamometer at 5 intervals of 25% increment (0%, 25%, 50%, 75%, 100%). Hydrogen is introduced into the throat with air at two different flow rates, 3LPM and 9LPM. The hydrogen air mixture comes in contact with the fuel in the chamber and combustion takes place. The fuel consumption is noted by measuring the time taken to consume 10 cc of fuel. Once the engine test is done, the fuel from

the engine is completely drained and the next test is conducted using a different fuel. The exhaust gas is made to pass through a Gas analyser with the help of pipes. The gas analyser gives the various percentages of the exhaust gas. This process is repeated with B10 and B20 blend of the Biofuel and the emission results of the exhaust gas is noted. A dynamometer is coupled to the engine to obtain the performance parameters like Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE).

CHAPTER 5

RESULTS AND DISCUSSION

5.1 CARBON MONOXIDE EMISSION

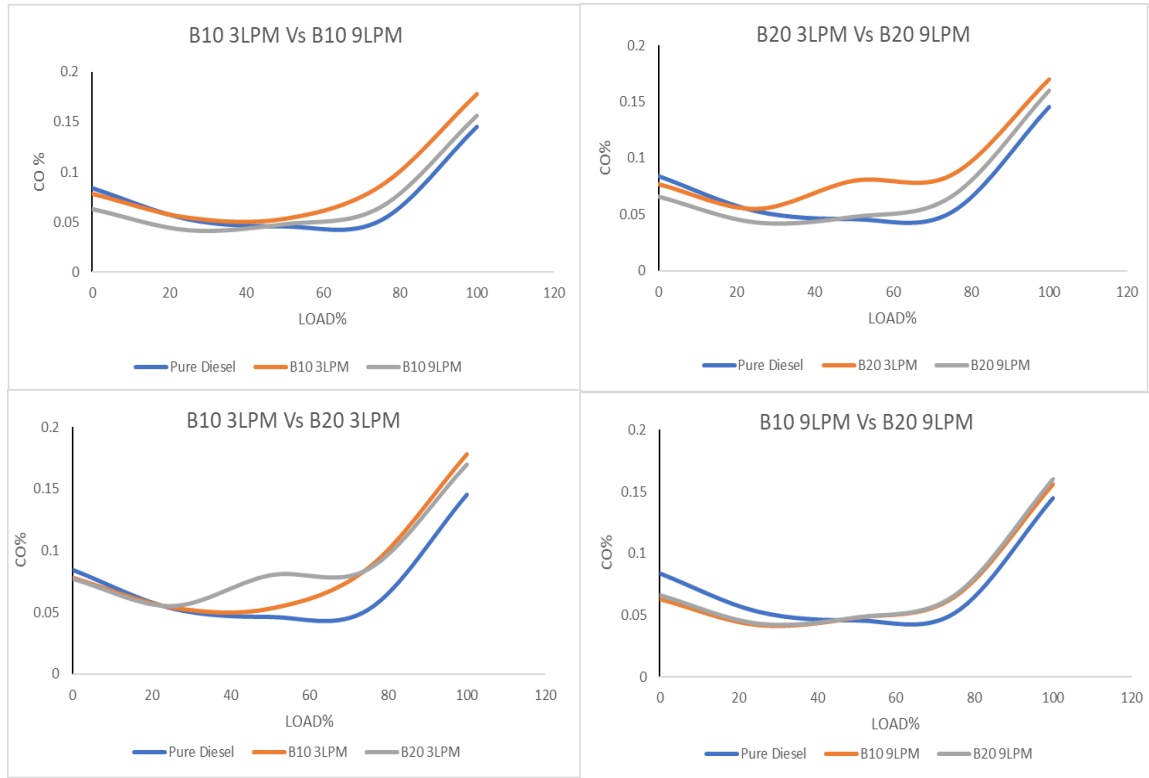


Fig 5.1 CO emission with respect to load

The above figure shows about the variation of Carbon Mono Oxide emission (CO emission) with respect to load in this we find the emission level of B10 and B20 fuels with respect to load. In Fig 5.1 B10 and B20 at 3LPM and 9LPM CO emissions are compared and it is observed there's a marginal difference compared to that of diesel in higher loads. Out of all the figures, B20 at 9LPM showed similar results to diesel. This emission occurs when there is increase in load and the emission is peaked at the maximum load. This increase in CO emission could be due to the incomplete combustion of hydrogen.

5.2 HYDROCARBON EMISSION

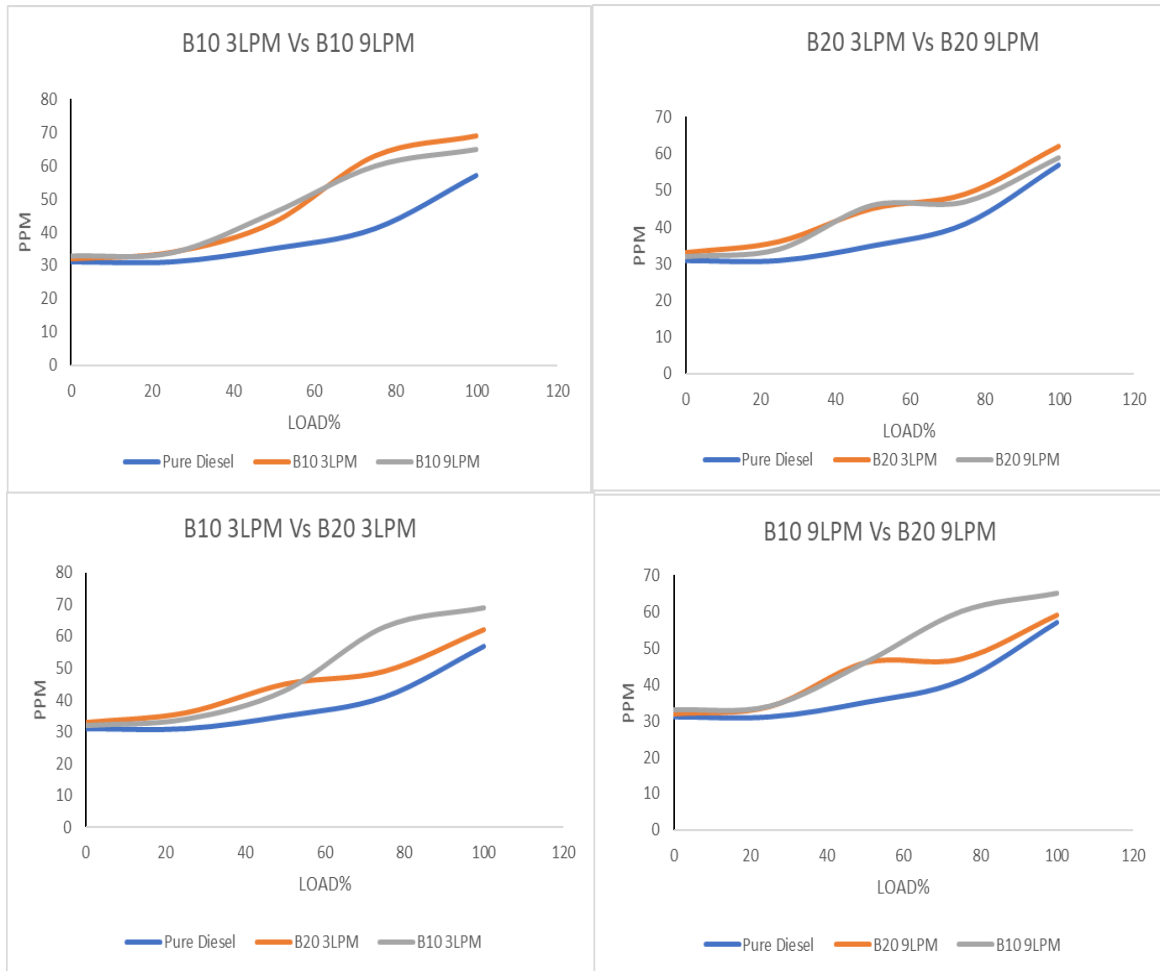


Fig 5.2 HC emission with respect to load

The emission of Hydrocarbons with respect to different loads in different tests are shown in the above figures. B20 blend with hydrogen produced at 3LPM and 9LPM are shown in Fig 5.2 to produce less hydrocarbon compared to B10 blends. At higher loads, where a lot of fuel is burned in less time would produce higher HC emission. The increase in HC emission could be because of poor combustion in the chamber. The mixture of excess hydrogen in the air might cause incomplete combustion resulting in unburnt hydrocarbons.

5.3 CARBON DIOXIDE EMISSION

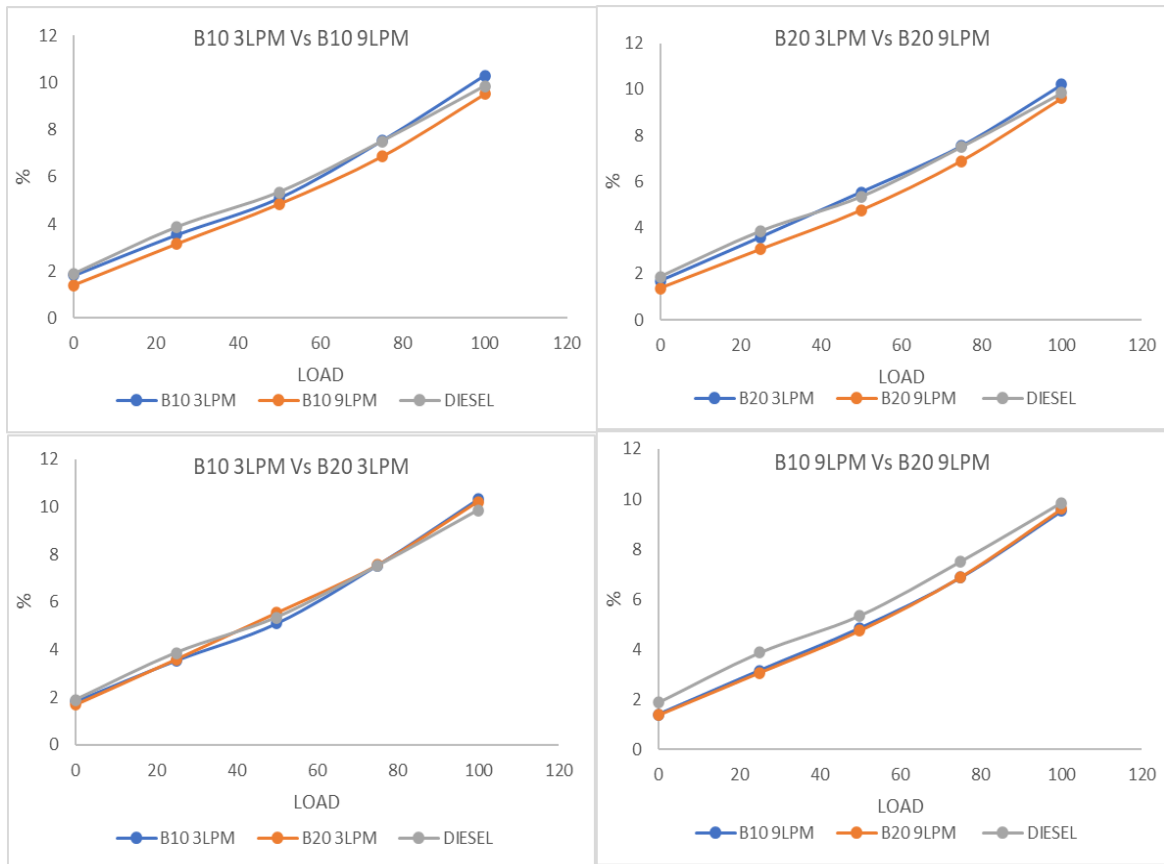


Fig 5.3 CO₂ emission with respect to load

The above figure 5.3 the emission of Carbon dioxide at different load at each test. It is noted that CO₂ emission is increased in each test with an increase in load. Usually, increased CO₂ emission is a result of good combustion in CI engine. It is observed CO₂ emission in all tests are similar to that of pure diesel. However, both B10 and B20 blend tested with hydrogen supplied at 9 LPM showed reduced CO₂ emission.

5.4 NITROGEN OXIDE EMISSION

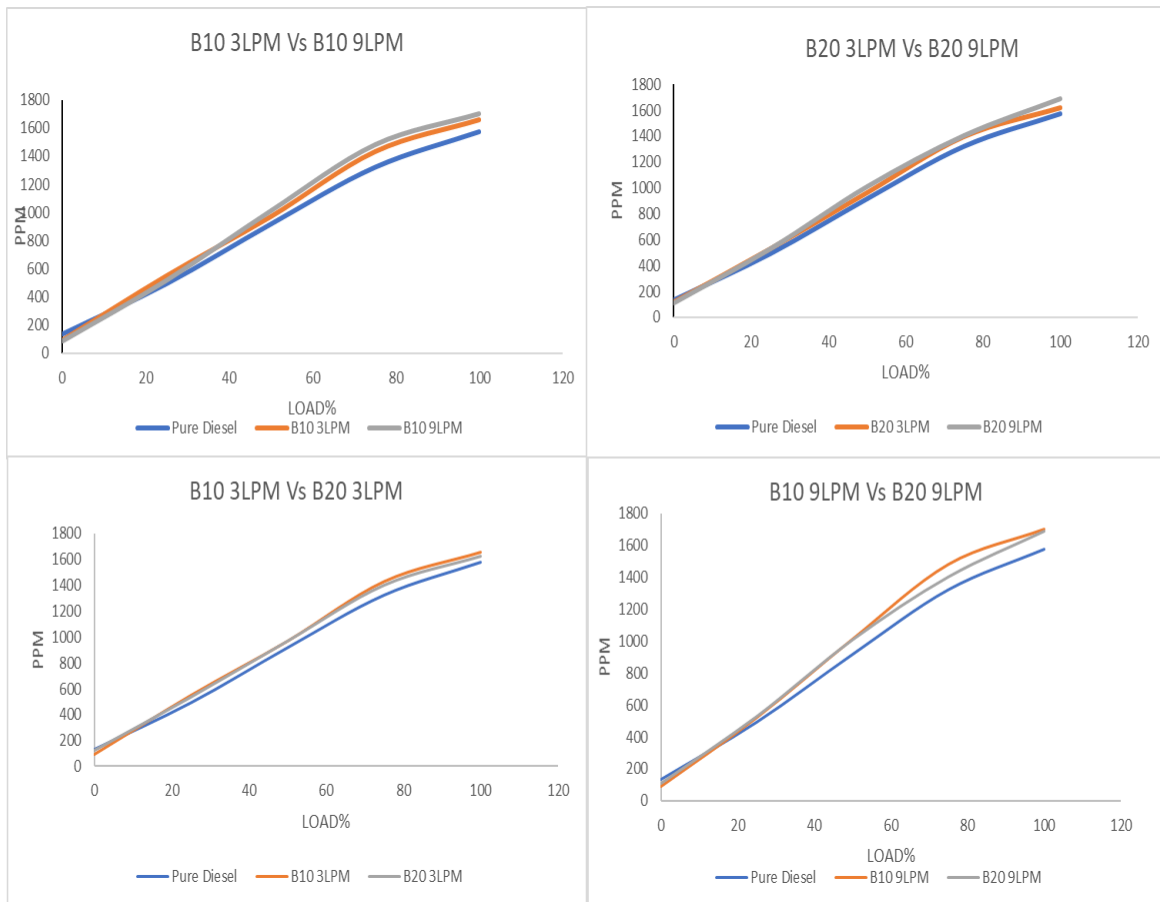


Fig 5.4 NOx emission with respect to load

The above figure 5.4 shows the variation in the Nitrogen oxide emission in the tests with respect to different load. Higher NOx emission is observed in 75% load and 100% load. This could be due to the lean mixture of fuel causing the mixture to burn hotter. This may also be due to presence of exhaust gas from previous cycle. From the B10 9 LPM Vs B20 9 LPM it is shown that B20 9 LPM had less emission than B10 at 9 LPM.

5.5 BRAKE THERMAL EFFICIENCY

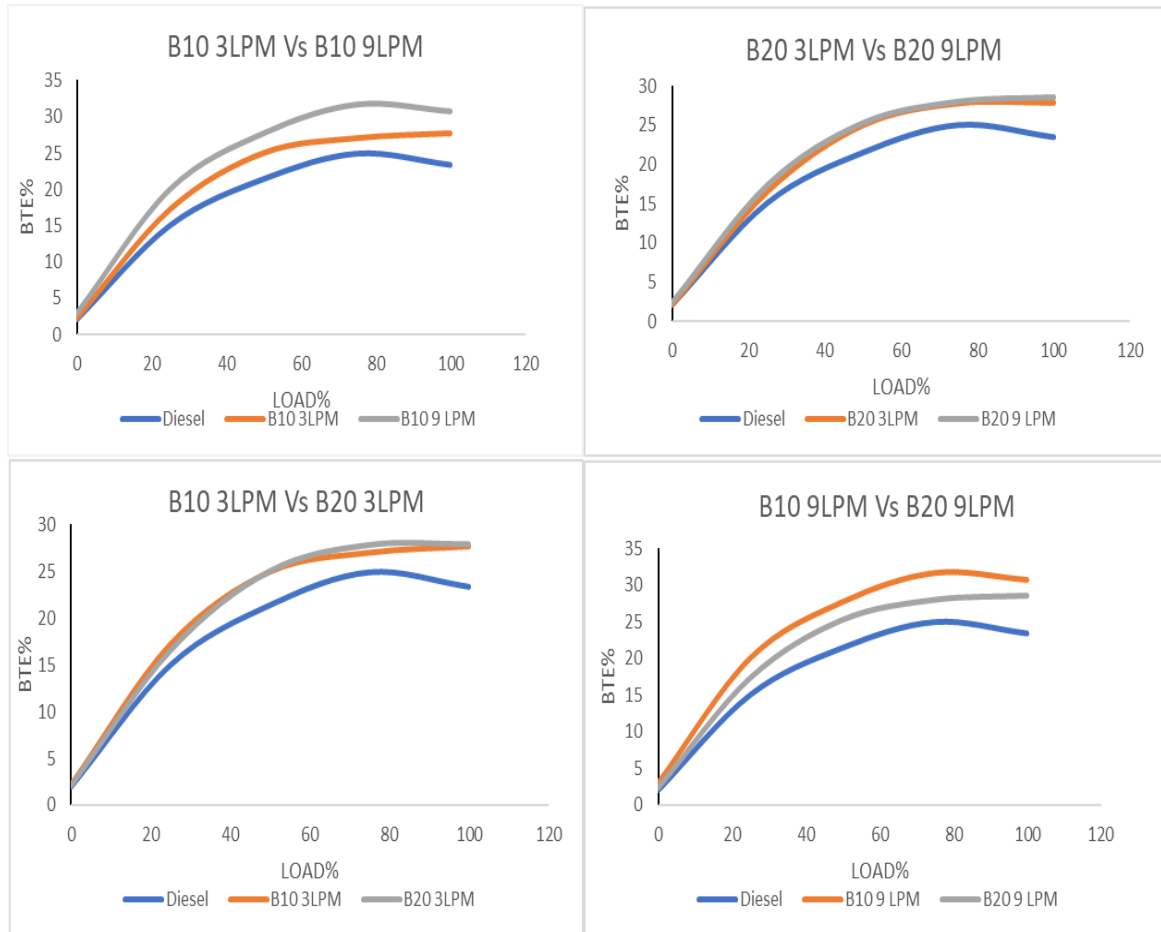


Fig 5.5 Brake Thermal Efficiency with respect to load

The above figures 5.5 shows that the Brake Thermal Efficiency (BTE) of B10 and B20 fuels respectively and from the graph we can know that there is efficiency of the B10 and B20 does not differ much from each other and increases gradually with the load and reaches a peak point at maximum load and with this we can find that the fuel emission and gas consumption is low in the fuels which result in maximum efficiency. This could be due to the addition of hydrogen in the combustion process

5.6 BRAKE SPECIFIC FUEL CONSUMPTION

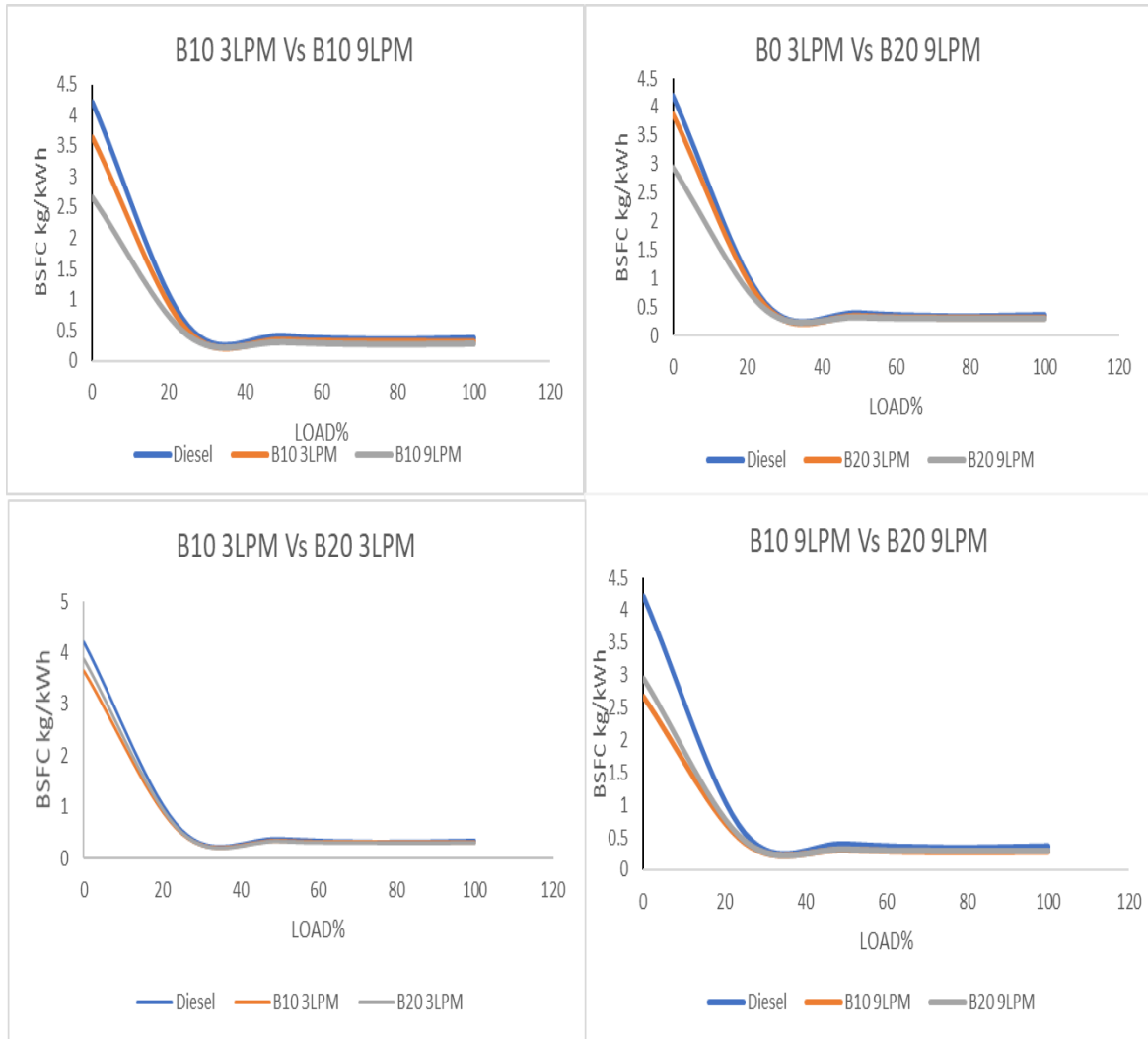


Fig 5.6 Brake Specific Fuel Consumption with respect to load

The above graph shows us about the Brake Specific Fuel Consumption (BSFC) for B10 and B20 fuels with respect to load and with this we find that the rate of fuel consumption is high for both the fuels and initial stages, and they decrease to the fullest as the load is increase to the maximum. As the BSFC power is high due to this the C.I engine efficiency is reduced and at maximum load the fuel consumption is reduced.

5.7 HEAT RELEASE RATE

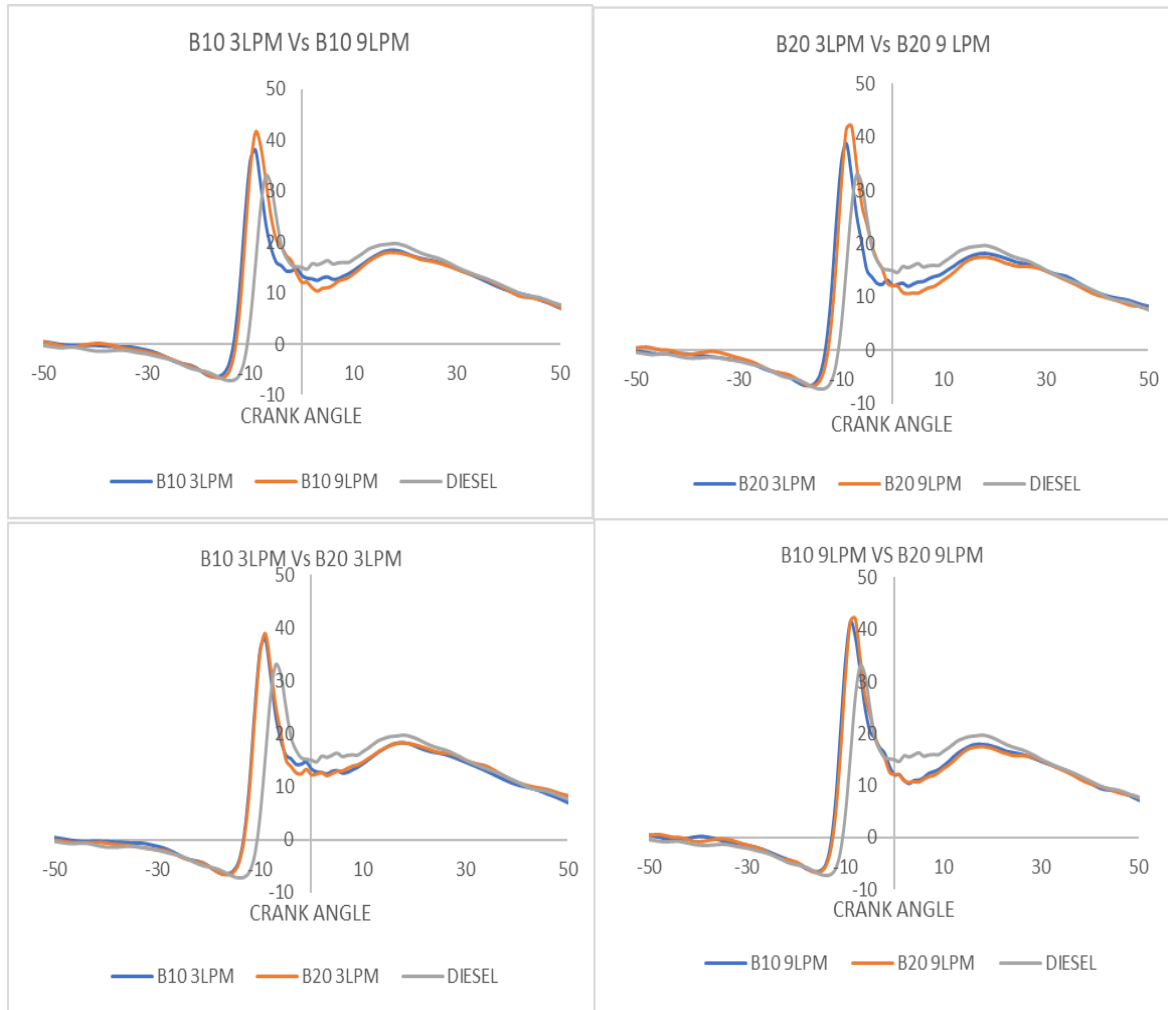


Fig 5.7 Heat Release Rate with respect to crank angle

The above graph shows the heat release rate in B10 and B20 fuels at 100 % load. From the Fig 5.7 it is observed that the B20 fuel at 9 LPM had higher heat release rate than diesel and the heat released for Biodiesel enhanced with 9 LPM showed better result than 3 LPM. The Heat release rate could be related with Pressure and crank angle as there an increase in increase in-cylinder there is an increase in HRR respectively. The decrease in HRR for B10 as shown could be due to the lower calorific value and high viscosity of the Biofuel.

5.8 PRESSURE AND CRANK ANGLE

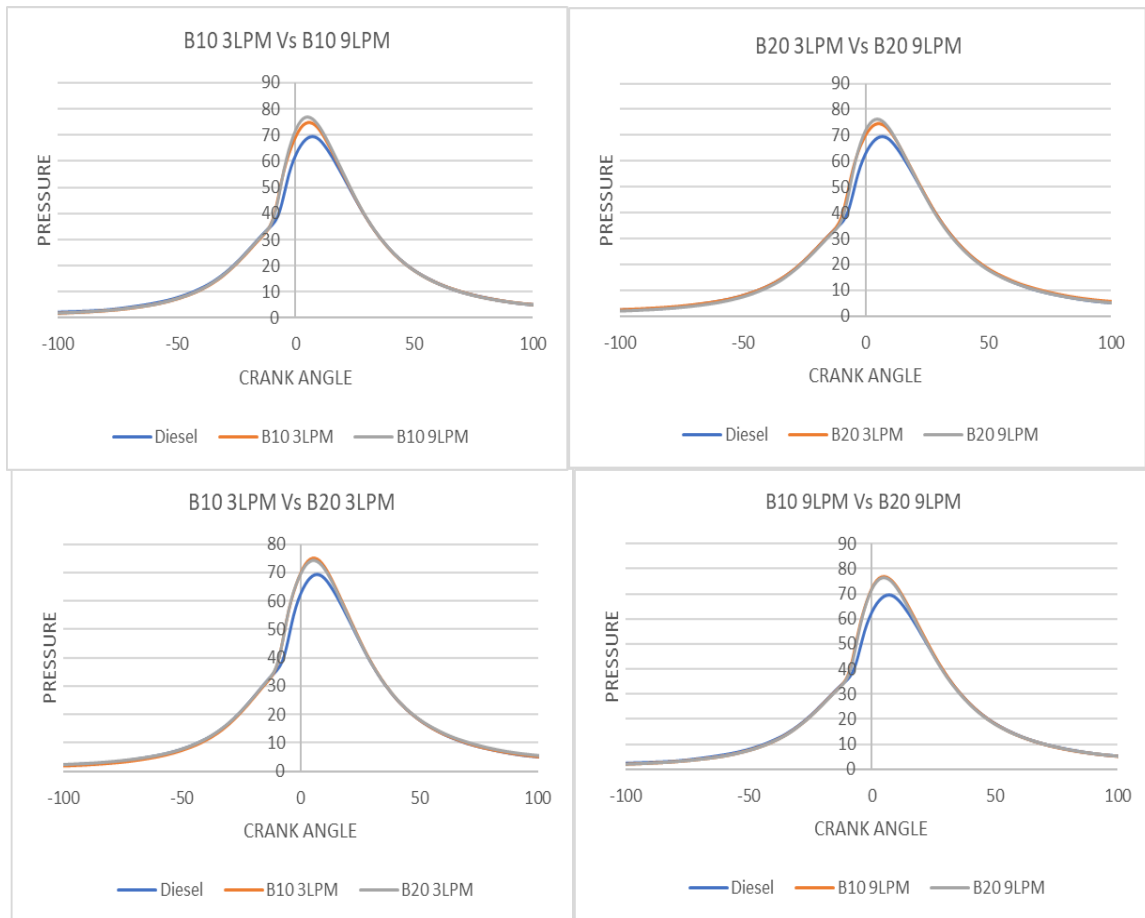


Fig 5.8 Pressure variation with respect to Crank Angle

The above Fig 5.8 shows the variation in pressure of B10 3 LPM , B10 9 LPM, B20 3 LPM and B20 9 LPM with respect to crank angle at 100 % load. From the graphs it is observed that there is an increase in pressure in all tests. By comparing all the test, B20 at 9 LPM showed better results than all the others. The increase in pressure shows that combustion has taken place properly with high heat release rate.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The Biodiesel is obtained from the pork fat using transesterification process with KOH as the catalyst and the biodiesel blends are tested in a CI engine while introducing hydrogen in the throat of the engine with air. The emission and performance graphs are drawn for different test. It is observed that the use of hydrogen with blended biodiesel increases the performance while keeping the emission similar to that of a diesel engine.

6.2 CONCLUSION

- The stability is high for KOH than the other. So, KOH can be easily dispersed with ethanol and other combination.
- KOH are effective catalysts for biodiesel production than NaOH . At the same molar concentration KOH is more active, but at the weight percentage their catalytic activities are approximately equal.
- It has been observed that Carbon Monoxide, Hydrocarbon, Nitrogen oxide and Carbon Dioxide emissions are similar to and marginally less than that of diesel in the tests taken.
- Carbon dioxide emissions are marginally reduced when the B20 blend is enhanced with Hydrogen at 9 LPM.
- Due to the hydrogen addition, the combustion temperature is increased resulting in increase in Nitrogen oxide. This increase in result is seen across all the tests.
- It is observed to have high Brake Thermal Efficiency in all tests when compared to diesel. Out of all tests, the blends tested at 9 LPM showed much better results in each blend.

- The Brake Specific fuel consumption is noted to be lower in B10 blends in comparison to pure diesel.
- The Heat release rate of B20 9 LPM has been the highest in all of the tests at 100% load.
- Due to higher heat release rate, increase in pressure has been observed in all four blends. B20 9 LPM had the highest-pressure crank angle.
- The performance of the engine is quite increased due to the introduction of hydrogen in the combustion process when compared to the performance results obtained from test without hydrogen enhancement.
- Out of all the test taken B20 at 9 LPM had the best results.

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