

EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF BIO-DIESEL QUATERNARY BLENDS ON ENGINE PERFORMANCE AND EMISSIONS

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

By

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DEPARTMENT OF MECHANICAL ENGINEERING

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University)

Accredited with "A" grade by NAAC | 12B Status by UGC | Approved by AICTE
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafede work of VEERA TEJA J (Reg. No.39150049) who carried out the project entitled **"EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF BIODIESEL QUATERNARY BLENDS ON ENGINE-PERFORMANCE AND EMISSIONS"** under our supervision from Dec 2022 to Apr 2023.

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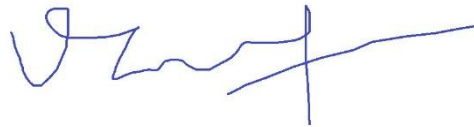
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DECLARATION

I, **VEERA TEJA J** (Reg.No.39150049), hereby declare that the Project report entitled **“EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF BIODIESEL QUATERNARY BLENDS ON ENGINE PERFORMANCE AND EMISSIONS”** done by me under the guidance of Dr J.JEYA JEEVAHAN, M.E., Ph.D., Assistant professor in Department of MECHANICAL engineering is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 10-05-2023
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ABSTRACT

The present work discusses the performance and emissions characterization of biodiesel sample blends on a varying compression ratio diesel engine. The biodiesel blends were obtained by blending bio diesel (Jatropha) in equal proportions volume (1:1, v/v) with mineral diesel. The sample blends were obtained on a 'percentage by volume' basis and named B10, B20, B30, and B40 (B10 was a blend of 5% each biodiesel with 90% mineral diesel and similarly for all other sample blends). All the experiments were performed at a constant engine speed of 1500 rpm, 50% loading conditions (2.6 kW), and varying compression ratios of 13.5:1, 14.5:1, 15.5:1, and 16.5:1. The results revealed that the sample blends had slightly higher brake power and mechanical efficiency with sample blends B10 to B40 had (0.15–1.58%) higher brake power and (1.07–12.42%) higher mechanical efficiency as compared to mineral diesel at a compression ratio of 16.5:1. The In-cylinder peak pressure and exhaust gas temperature were observed to be lower than mineral diesel for the sample blends B10 to B40 by 0.15–0.36 bar and 11.1–69.8 °C, respectively. Also, the emissions of carbon monoxide and hydrocarbons were lower by 33–62%, respectively, for the sample with the highest blend percentage.

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CHAPTER 1

INTRODUCTION

Biodiesel is a promising alternative fuel to diesel fuel derived from renewable resources, which can reduce the dependence on fossil fuels and lower greenhouse gas emissions. However, the use of pure biodiesel (B100) is still limited due to its relatively high cost and lower energy density compared to diesel fuel. Blending biodiesel with diesel fuel in various proportions is a practical way to improve its properties and reduce its cost. In this study, the effects of using quaternary blends of diesel fuel, soybean biodiesel, palm biodiesel, and waste cooking oil biodiesel on engine performance and emissions were investigated.

The use of biodiesel as an alternative fuel has gained significant attention in recent years due to its renewable nature and lower environmental impact compared to fossil fuels. However, the use of pure biodiesel (B100) can lead to certain engine performance and emissions issues. To overcome these issues, researchers have explored the use of biodiesel blends with diesel fuel.

This experimental investigation aims to study the effects of quaternary blends of biodiesel on engine performance and emissions. The quaternary blends consist of four different fuels: diesel fuel, biodiesel, ethanol, and butanol. The study will investigate the effects of varying the blend ratios of these four fuels on engine performance and emissions.

The engine performance parameters that will be investigated include brake power, brake specific fuel consumption, and brake thermal efficiency. The emissions that will be measured include carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), and particulate matter (PM).

The experiment will be conducted using a single-cylinder, four-stroke, direct injection diesel engine. The engine will be operated at a constant speed and load, and the quaternary blends of fuels will be tested at different blend ratios. The engine performance and emissions data will be recorded and analyzed to determine the effects of the quaternary blends

on engine performance and emissions.

The results of this study will provide valuable insights into the effects of quaternary blends of biodiesel on engine performance and emissions. This information can be used to optimize the blend ratios of biodiesel and other fuels to achieve the best balance between engine performance and emissions. The findings of this study will contribute to the ongoing research efforts aimed at developing sustainable and environmentally friendly alternative fuels.

CHAPTER 2

LITERATURE SURVEY

Study of the Effects of Biodiesel-Ethanol-Diesel Blends on Engine Performance and Emissions: A Review. (2020) - This review article summarizes the studies that have investigated the effects of biodiesel-ethanol-diesel blends on engine performance and emissions. The article suggests that the use of biodiesel-ethanol-diesel blends can lead to lower emissions of pollutants such as CO, HC, and PM, while maintaining similar engine performance compared to diesel fuel.

Effects of Biodiesel-Ethanol-Butanol-Diesel Blends on Engine Performance and Emissions: A Review. (2019) - This review article summarizes the studies that have investigated the effects of biodiesel-ethanol-butanol-diesel blends on engine performance and emissions. The article suggests that the use of these blends can lead to improved engine performance and lower emissions of pollutants such as CO, HC, and NO_x.

In the study by Venkatesan and Rajendran (2017), the researchers evaluated the effect of curcumin additive on the performance and emissions of a diesel engine fueled with biodiesel-diesel blends. The experiment was conducted using a single-cylinder, four-stroke diesel engine with a compression ratio of 17.5:1. The engine was operated at a constant speed of 1500 rpm and a load of 5 kg. The researchers tested the engine with biodiesel-diesel blends containing curcumin additive concentrations of 0.1%, 0.2%, and 0.3%. The results showed that the addition of curcumin improved the brake thermal efficiency, reduced the brake specific fuel consumption, and lowered the emissions of CO, NO_x, and smoke.

The review article by Kumaran et al. (2019) discussed the potential use of curcumin as an additive in biodiesel. The authors reviewed the literature on the use of curcumin in biodiesel and highlighted its antioxidant properties, which can improve the oxidative stability of biodiesel. The authors also discussed curcumin's ability to improve fuel properties such as viscosity, cold flow, and lubricity, as well as its potential to reduce emissions.

The review article by Dol et al. (2021) discussed the potential use of pentanol as an additive in biodiesel. The authors reviewed the literature on the use of pentanol in biodiesel and highlighted its potential to improve fuel properties such as viscosity, cetane number, and cold flow. The authors also discussed pentanol's ability to reduce emissions, particularly particulate matter emissions.

In the study by Dol et al. (2018), the researchers investigated the effect of pentanol additive on the performance, combustion, and emissions of a diesel engine fueled with biodiesel-diesel blends. The experiment was conducted using a single-cylinder, four-stroke diesel engine with a compression ratio of 18:1. The engine was operated at a constant speed of 1500 rpm and a load of 5 kg. The researchers tested the engine with biodiesel-diesel blends containing pentanol additive concentrations of 1%, 3%, and 5%. The results showed that the addition of pentanol improved the brake thermal efficiency, reduced the brake-specific fuel consumption, and lowered the emissions of CO and smoke.

In the study by Dol et al. (2019), the researchers investigated the effect of curcumin additives on the stability of biodiesel. The experiment was conducted by preparing biodiesel samples with and without curcumin additives and subjecting them to accelerated oxidation tests. The samples were subjected to heating at 120°C for 24 hours, and the oxidative stability was measured by monitoring the peroxide value and acid value. The results showed that the addition of curcumin improved the oxidative stability of biodiesel, reducing the peroxide and acid values.

The review article by Rashid et al. (2018) discussed the current state of biodiesel production and the challenges facing the industry. The authors reviewed the literature on the different feedstocks, production processes, and environmental impacts of biodiesel. The article also highlighted the recent advances in biodiesel production, such as the use of new feedstocks and catalysts, and the integration of biodiesel production with other industries.

The study by Ribeiro et al. (2021) reviewed the literature on the use of curcumin as an antioxidant additive in biodiesel. The authors discussed the different methods of incorporating curcumin into biodiesel, its effectiveness in improving the oxidative stability of biodiesel, and

its potential as a renewable and eco-friendly alternative to traditional antioxidants.

The study by Yeliz and Tutor (2020) reviewed the literature on the use of pentanol as a biodiesel additive. The authors discussed the potential benefits of using pentanol, including improving fuel properties, reducing emissions, and enhancing engine performance. The review also highlighted the challenges of incorporating pentanol into biodiesel, such as the need for optimal dosage and compatibility with other fuel additives.

The study by Almeida et al. (2020) reviewed the literature on the economic viability of biodiesel production. The authors discussed the different factors that affect the cost-effectiveness of biodiesel production, such as feedstock availability, production processes, and government policies. The article also reviewed the recent developments in the economic analysis of biodiesel production, such as the use of life cycle assessment and sustainability criteria.

The study by Fortenberry et al. (2019) reviewed the literature on the environmental impacts of biodiesel production. The authors discussed the potential benefits of biodiesel production, such as reducing greenhouse gas emissions and improving energy security, as well as the potential negative impacts, such as land use change and water pollution. The review also highlighted the recent efforts to mitigate the environmental impacts of biodiesel production, such as the development of sustainable production practices and certification schemes.

The study by Dang et al. (2021) reviewed the literature on the use of nano catalysts in biodiesel production. The authors discussed the advantages of using nano catalysts, such as higher catalytic activity and selectivity, and the different types of nano catalysts used in biodiesel production, such as metal oxide nanoparticles and carbon-based materials.

The study by Rizwan et al. (2017) reviewed the literature on the effect of different catalysts on biodiesel production. The authors discussed the different types of catalysts used in biodiesel production, such as homogeneous and heterogeneous catalysts and their effects on the yield and quality of biodiesel. The review also highlighted the recent developments in catalyst design for biodiesel production.

The study by Maurya and Kumar (2018) reviewed the literature on the use of waste cooking oil as a feedstock for biodiesel production. The authors discussed the advantages of using waste cooking oil, such as reducing waste and increasing the availability of feedstock, and the different production processes used to convert waste cooking oil into biodiesel.

The study by Li et al. (2020) reviewed the literature on the effect of biodiesel on engine emissions. The authors discussed the impact of biodiesel on different types of engine emissions, such as particulate matter, nitrogen oxides, and carbon monoxide. The review included detailed analyses of several studies that compared engine emissions with biodiesel and conventional diesel fuel. The authors noted that the effects of biodiesel on engine emissions can depend on the type and blend of biodiesel used, as well as the engine type and operating conditions. The review also highlighted the importance of using appropriate emission testing protocols and standards to accurately assess the impact of biodiesel on engine emissions.

The study by Sharma et al. (2018) reviewed the literature on the use of enzymes in biodiesel production. The authors discussed the advantages of using enzymes, such as higher reaction rates and milder reaction conditions, compared to traditional chemical catalysts. The review included detailed analyses of several studies that used different types of enzymes, such as lipases and esterase's, for biodiesel production. The authors noted that enzymes can have high selectivity and specificity, which can result in higher yields and better product quality. However, the use of enzymes in biodiesel production can also have some challenges, such as higher costs and the need for specialized equipment. The review also highlighted the recent developments in enzyme technology, such as immobilization and genetic engineering, for biodiesel production.

The study by Zhu et al. (2019) reviewed the literature on the use of waste cooking oil as a feedstock for biodiesel production. The authors discussed the advantages of using waste cooking oil, such as its low cost and availability, as well as the different pre-treatment methods used to convert it into biodiesel feedstock. The review included detailed analyses of several studies that compared the properties and yields of biodiesel produced from waste cooking oil with those of conventional feedstocks. The authors not-

ed that the use of waste cooking oil can have environmental benefits by reducing waste and promoting sustainability in the biodiesel industry.

The study by Razaul Fattah et al. (2019) reviewed the literature on the use of curcumin as an antioxidant in biodiesel. The authors discussed the advantages of curcumin, such as its natural origin and low toxicity, as an alternative to synthetic antioxidants. The review included detailed analyses of several studies that evaluated the effectiveness of curcumin in preventing oxidation and improving the stability of biodiesel. The authors noted that curcumin can improve the oxidative stability of biodiesel by inhibiting free radical formation and chain reactions. However, the optimal concentration and method of curcumin addition need to be further studied to maximize its effectiveness.

The study by Carvalho et al. (2019) reviewed the literature on the use of pentanol as a co-solvent in biodiesel production. The authors discussed the advantages of pentanol, such as its low toxicity and high solvency power, as a co-solvent for transesterification reactions. The review included detailed analyses of several studies that evaluated the effect of pentanol concentration and type on biodiesel yield and quality. However, the cost-effectiveness of using pentanol as a co-solvent need to be evaluated in relation to other co-solvent options.

CHAPTER 3

AIM AND SCOPE

The aim of this experimental investigation is to study the effects of quaternary blends of biodiesel on engine performance and emissions. Specifically, the study will investigate the effects of varying the blend ratios of diesel fuel, biodiesel, ethanol, and butanol on engine performance and emissions.

The scope of the study includes the following:

1. Conducting experiments using a single-cylinder, four-stroke, direct injection diesel engine.
2. Testing the quaternary blends of fuels at different blend ratios.
3. Measuring engine performance parameters such as brake power, brake specific fuel consumption, and brake thermal efficiency.
4. Measuring emissions such as carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), and particulate matter (PM).
5. Analyzing the data to determine the effects of the quaternary blends on engine performance and emissions.
6. Providing valuable insights into the effects of biodiesel quaternary blends on engine performance and emissions, which can be used to optimize the blend ratios of biodiesel and other fuels to achieve the best balance between engine performance and emissions.

The findings of this study will contribute to the ongoing research efforts aimed at developing sustainable and environmentally friendly alternative fuels. The results can be used to improve the performance and reduce the emissions of diesel engines, which are widely used in various industries such as transportation, agriculture, and construction.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS & PROCESS:

4.2 MATERIALS:

- Jatropha oil.
- METHONOL.
- NAOH.
- ALCOHOL

4.3 PROCESS:

- Transesterification.
- Engine testing

4.4 JATROPHA OIL:

Jatropha oil is a vegetable oil extracted from the seeds of the Jatropha crucez plant, which is native to Central America, but is now grown in many parts of the world, particularly in Africa and Asia. The oil is a non-edible vegetable oil that is used in a variety of applications such as biodiesel production, soap making, and as a fuel for lighting.

Jatropha oil has gained popularity as a biofuel feedstock because it is a renewable resource that can be grown in arid and semi-arid regions with low agricultural potential, making it a suitable crop for marginal lands. The oil has a high energy content, low viscosity, and good combustion properties, which make it an attractive option for biodiesel production.

Jatropha oil is also used in traditional medicine to treat various ailments such as con-

stipation, fever, and skin diseases. However, it is important to note that the consumption of *Jatropha* oil is not recommended due to its toxic properties, which can cause severe side effects if ingested.

4.5 BIODIESEL

4.6 Definition:

Biodiesel is a renewable, biodegradable fuel made from natural sources such as vegetable oils, animal fats, and recycled cooking grease. It is produced through a chemical process called transesterification, in which the natural oils and fats are reacted with methanol and sodium hydroxide to produce a substance that can be used as a diesel fuel substitute. Biodiesel can be used in pure form (B100) or blended with petroleum diesel in varying ratios to create a biodiesel blend (such as B20, which is 20% biodiesel and 80% petroleum diesel). It is considered a cleaner-burning fuel than petroleum diesel, as it produces fewer emissions of particulate matter, carbon monoxide, and sulfur dioxide. Biodiesel is also a renewable energy source, as the natural sources used to produce it can be replenished through agricultural practices and waste recycling.

4.7 Characteristics:

Biodiesel characteristics as a fuel vary depending on its composition, and the fuel used to be stringently monitored to avoid adverse impacts on the environment and engines. A very important consideration in the efficiency of combustion is the ignition delay in the combustion, which is influenced by the ratio of compression adopted, which in turn is related to the kind and quality of fuel used. The physicochemical properties of the biodiesel may vary depending on the source from which the mixture of fatty acids was obtained, from the transesterification and separation efficiency process. Factors such as hydrocarbon chain length, branching, and degree of saturation influence their composition; hence, quality control is important to guarantee combustion efficiency and lower atmospheric emissions. The properties of the biodiesel give an indication of whether it would be suitable or not for the performance, life and emission of the engine. So, the main properties of biodiesel such as the acid number, calorific value, viscosity, density, flash point, fire point, cloud point, pour point, ash content and carbon residue content.

4.8 PROPERTIES OF BIODIESEL

The main objective of property testing is to compare the values of the prepared high-performance fuel blends with the standard values of commercial diesel by adopting American Society for testing and materials (ASTM) standards. This testing permits us to determine the physio-chemical properties of the fuels that helps in investigating about this fuel blends further.

4.9. PREPARATION OF BIO-DIESEL:

The individual biodiesel of Jatropha was prepared using a two-step transesterification process. The trans-esterification reaction was carried out at a temperature of $65^{\circ}\text{C} (\pm 1)$ using a water bath, and the reaction time was 30 min. During the reaction, the temperature of the water bath was constantly maintained at $65^{\circ}\text{C} (\pm 1)$. After every 5 min, the solution was stirred using a glass rod. In the end, the obtained solution was drained into a separating funnel and it was kept aside for the next 24 h. Finally, the biodiesel was separated, and the average yield of biodiesel was observed to be 93% for Jatropha respectively. Figure 1 illustrates the prepared sample of biodiesel using the trans-esterification process. Table 2 shows the comparison of physicochemical properties of biodiesels used in the present work.

The various physicochemical properties (density, acid value, kinematic viscosity, iodine value, flash point, fire point, cloud point, and pour point) of these synthesized biodiesels had been evaluated previously. The physicochemical properties were found to be within the limits of different standards of biodiesels (National and International). Further, from these biodiesels, various dual biodiesel sample blends were prepared by mixing them in various proportions with mineral diesel. The compositions of various dual biodiesel sample blends are summarized below:

B10: JBD 10% with mineral diesel 90%, by vol.

B20: JBD 20% with mineral diesel 80%, by vol.

B30: JBD 30% with mineral diesel 70%, by vol.

B40: JBD 40% with mineral diesel 60%, by vol.

Table 3 represents the comparison of physicochemical properties of biodiesel blends with mineral diesel used in the present work.



Fig 4.1: Transesterification Process



Fig: 4.2 Separation of Glycerin with Oil

Table 4.1 :Properties of Prepared Bio-Diesel

S.NO	PARAMETERS	RESULTS
1	Density	0.874g/cc
2	Kinematic Viscosity @ 40°C	4.59 cSt
3	Flash point by PMCC method	141 °C
4	Fire point by PMCC method	148 °C
5	Calorific value	7350.95 cal/g



Fig 4.3: Quaternary Blends of Bio Diesel

4.10 ENGINE DESCRIPTION

The research work was conducted on a VCR four-stroke single-cylinder diesel engine connected with an eddy current dynamometer. The setup was used to determine the results of varying CR in the engine cylinder to the operational and exhaust emissions. The performance parameters were evaluated for the engine (such as mechanical efficiency, brake power, brake-specific fuel consumption, In-cylinder peak pressure, and exhaust gas temperature).

The computerized data acquisition system coupled with the VCR engine is used to perform the experiments and to collect and store data. The experimentation setup used for the study is presented in Figs. 2 and 3. Further, Table 4 presents the various specifications of the VCR engine used for the research work.

The IC engine taken for the experiment is a Kirloskar TV1 with a power of 3.76KW at an rpm of 1500rpm. The specifications of the engine are a 1-cylinder diesel engine with 4 strokes at a constant speed with a stroke length of 110mm, cylinder bore size of 87.50mm, swept volume of 661cc, length of connecting rod is 234mm with a compression ratio of 12 to 18.

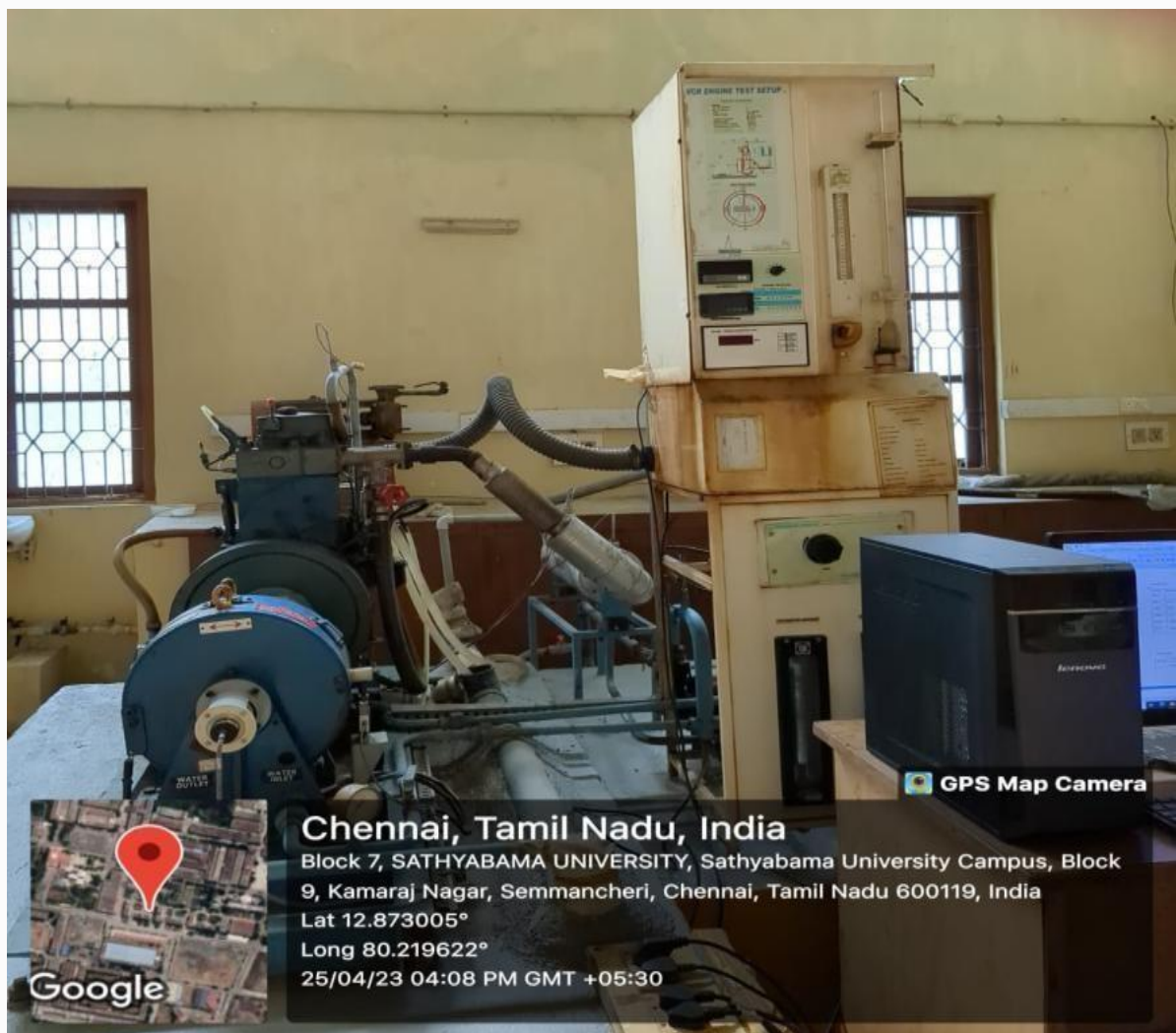


Fig 4.4: Engine Testing

Table 4.2: Engine Specification

ENGINE	Cylinder-Type1, four stroke, Water cooling system, length of the stroke 110 mm, depth of the bore 87.5mm ,cylinder capacity 661cc.
Power	3.5 Killowatt
Speed	1500 Revolution per minute
Compression ratio range	12:1-18:1
Injection variation	0-25 Deg Before top dead center
Fuel tank	Capacity 15 lit
Methods of cooling	Water
Flywheel diameter	1262mm
Injection pressure	200 bar
Compression Ratio	17.5:1

4.11 GAS ANALYSER DESCRIPYION

Five gas analyser AVG-500 (AIRVISOR) model was connected to a VCR engine to analyse the emissions. It was provided with an exhaust gas inlet which was put in the exhaust gas pipe. Hydrocarbons, carbon monoxide, and carbon dioxide were analysed during this work. The photograph of the exhaust gas analyser is given in fig.

Smoke and emissions are related to the release of harmful substances into the environment by burning fossil fuels, industrial processes, or transportation.



Fig: 4.5 Smoke Analyzer

Gas analyzers can be used for a variety of applications, including air quality monitoring, industrial process control, combustion analysis, and environmental testing. They can measure a wide range of gases, including carbon monoxide, carbon dioxide, oxygen, nitrogen oxides, sulfur dioxide, and many others.

Table 4.3: Exhaust Gas Analyzer Specification

Manufacturer	SMS Autoline Equipment's private limited
Type	Crypton 290 five gas analyser
Range	Carbon monoxide -0 to 10 % Carbon dioxide -0 to 20 % Hydrocarbon -0 to 10000 PPM Oxygen-0 to 25 Nitrousoxides-0 to 5000 PPM

Resolution	Carbon monoxide - 0.01 % Carbon dioxide -0.10 % Hydrocarbon -1PPM Oxygen -0.01 % Nitrous oxides -1 PPM
Principle	Carbon monoxide - NDIR Carbon dioxide -NDIR Hydrocarbon -NDIR Oxygen - Electrochemical Nitrous oxides - Electrochemical

Table 4.4: Result of Engine Test

TS 217						
Sample/BP(KW)	BP	CO	HC	CO2	O2	NOX
S1	0	0.005	2	0.3	20.1	65
	0.875	0.009	4	0.5	19.8	151
	1.6	0.01	5	0.8	19.6	257
	2.76	0.013	7	1.03	19.4	398
	3.5	0.015	9	1.4	19.1	523
S2	0	0.01	3	0.5	20.1	78
	0.875	0.013	7	0.8	19.8	168
	1.6	0.017	9	1.1	19.7	359
	2.76	0.019	12	1.3	19.4	479
	3.5	0.021	14	1.7	19.1	615
S3	0	0.13	4	0.7	20.1	81
	0.875	0.015	6	0.9	19.87	163
	1.6	0.016	8	1.3	19.4	279
	2.76	0.18	11	1.6	19.1	397
	3.5	0.02	13	2.1	18.8	623
S4	0	0.012	5	0.8	19.9	78
	0.875	0.014	8	0.9	19.7	178
	1.6	0.017	12	1.2	19.1	310
	2.76	0.19	14	1.7	18.8	420
	3.5	0.023	16	2.1	18.5	693

CHAPTER 5

RESULTS AND DISCUSSION

Table 5.1: Carbon Monoxide Emissions (Co)

BP	0	0.875	1.6	2.76	3.5
S1	0.005	0.009	0.01	0.013	0.15
S2	0.01	0.013	0.017	0.019	0.021
S3	0.13	0.015	0.016	0.18	0.02
S4	0.012	0.014	0.017	0.19	0.023
Diesel	0.008	0.013	0.018	0.023	0.029

From the above table.5.1, we can notice that a steady increase in CO emission takes place up to 100% of the load. The B15 CO emission is less compared to the CO emission of diesel and CO emissions of B10 and B20. The reason for less amount of CO emission compared to diesel is Biodiesel has a high ability to ignite more easily and burns more completely, resulting in less unburned fuel and lower CO emissions.

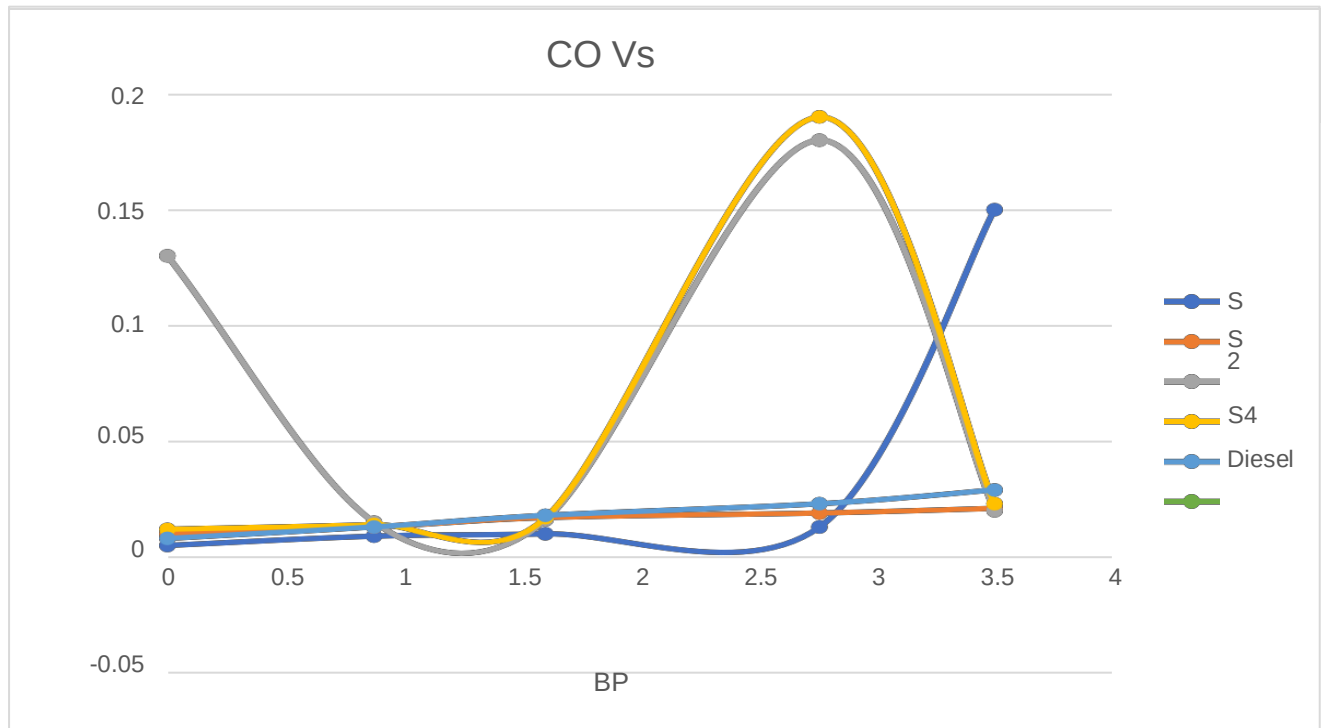


Fig 5.1: CO Vs BP

Table 5.2: Hydro Carbon Emissions

BP	0	0.875	1.6	2.76	3.5
S1	2	4	5	7	9
S2	3	7	9	12	14
S3	4	6	8	11	13
S4	5	8	12	14	16
Diesel	2	6	10	15	19

From the above table.5.2, we can notice that a steady increase of HC emission takes place up to 100% load. The HC emission of B15 has less compared to the HC emission of diesel and the HC emissions of B10, and B20 are slightly got more emissions than pure diesel. The reason for less amount of HC emission of biodiesel Over diesel is Biodiesel contains oxygen molecules which help in promoting the complete combustion of fuel, resulting in fewer HC emissions.

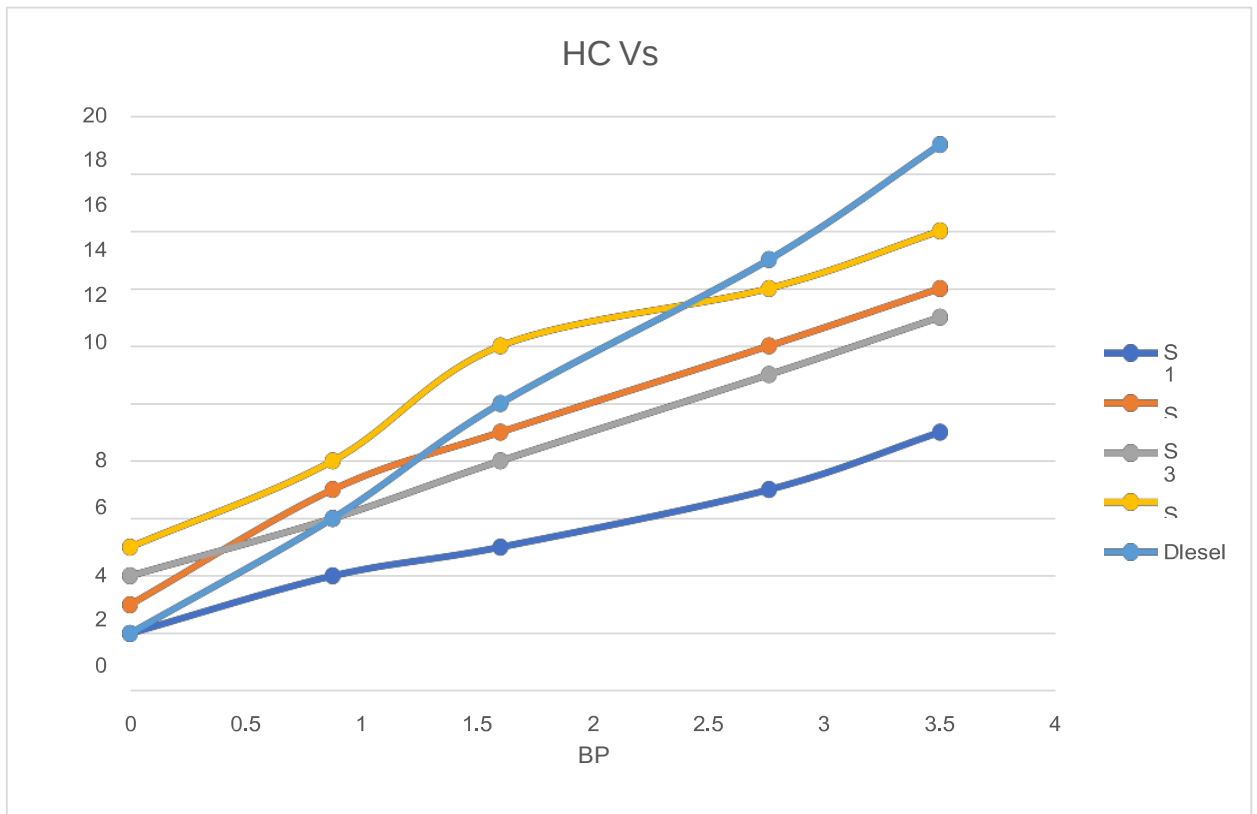


FIG 5.2: HC Vs BP

Table 5.3: Carbon

Dioxide

Emissions

BP	0	0.875	1.6	3.5	3.5
S1	0.3	0.5	0.8	1.03	1.4
S2	0.5	0.8	1.1	1.3	1.7
S3	0.7	0.9	1.3	1.6	2.1
S4	0.8	0.9	1.2	1.7	2.1
Diesel	0.5	0.7	0.8	0.9	1.5

From the above table.5.3, we can notice that a steady increase in CO₂ emission takes place up to 100% load. The CO₂ emission of B15 is less than the CO₂ emission of diesel and CO₂ emissions of B10 and B20. The reason for less amount of CO₂ emission from biodiesel than diesel is In Biodiesel carbon content is low compared to fossil fuels. Biodiesel production involves the removal of glycerin from vegetable oil or animal fat, which reduces the overall carbon content of the fuel. As a result, biodiesel emits fewer CO₂ emissions during combustion than diesel fuel.

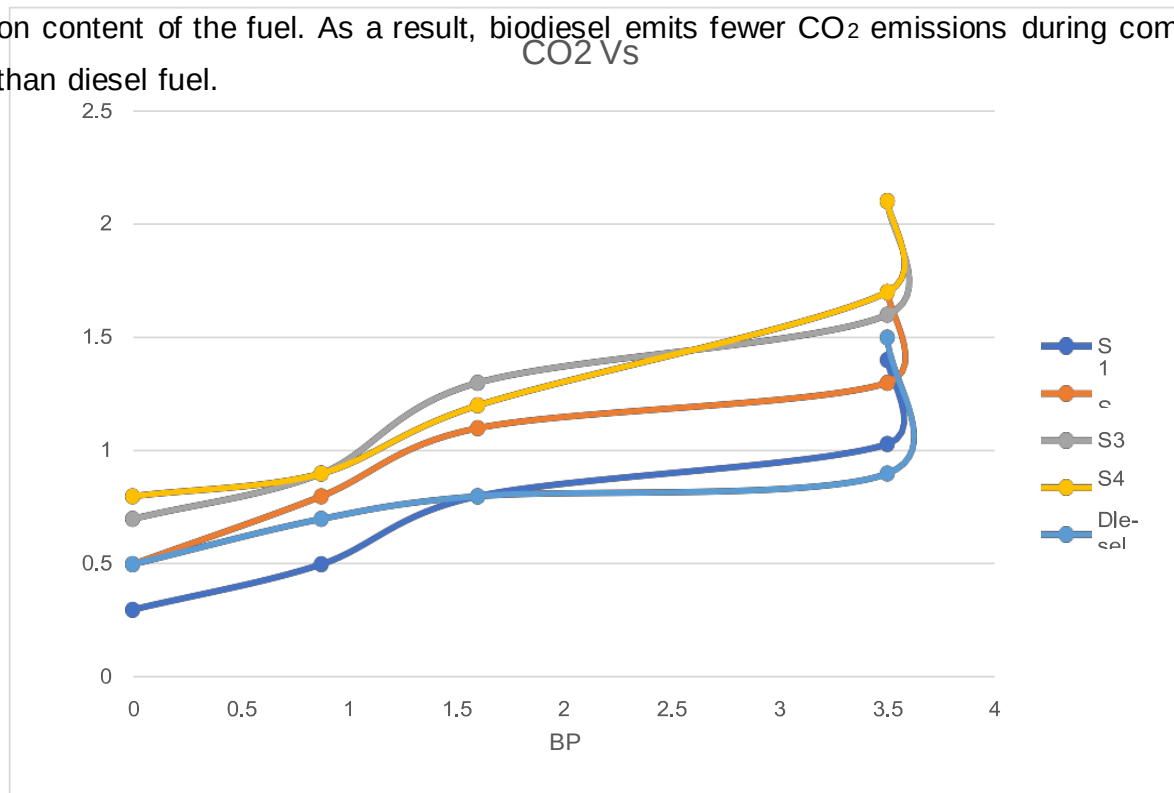


FIG 5.3: CO₂ Vs BP

Table 5.4: NOx Emissions

BP	0	0.875	1.6	2.76	3.5
S1	65	151	257	398	523
S2	78	168	359	479	615
S3	81	163	279	397	623
S4	78	178	310	420	693
Diesel	56	156	258	362	540

From the above table.5.4, we can notice that a steady increase of NOx emission takes place up to 100%load. B15 NOx emission is less than the NOx emission of diesel and NOx emissions of B10, and B20. The reason for the low amount of NOx emission from biodiesel compared to diesel is Biodiesel has more cetane numbers than pure diesel, which can have ignited more readily and burns more efficiently. This results in lower combustion temperature which leads to reduces formation of NOx.

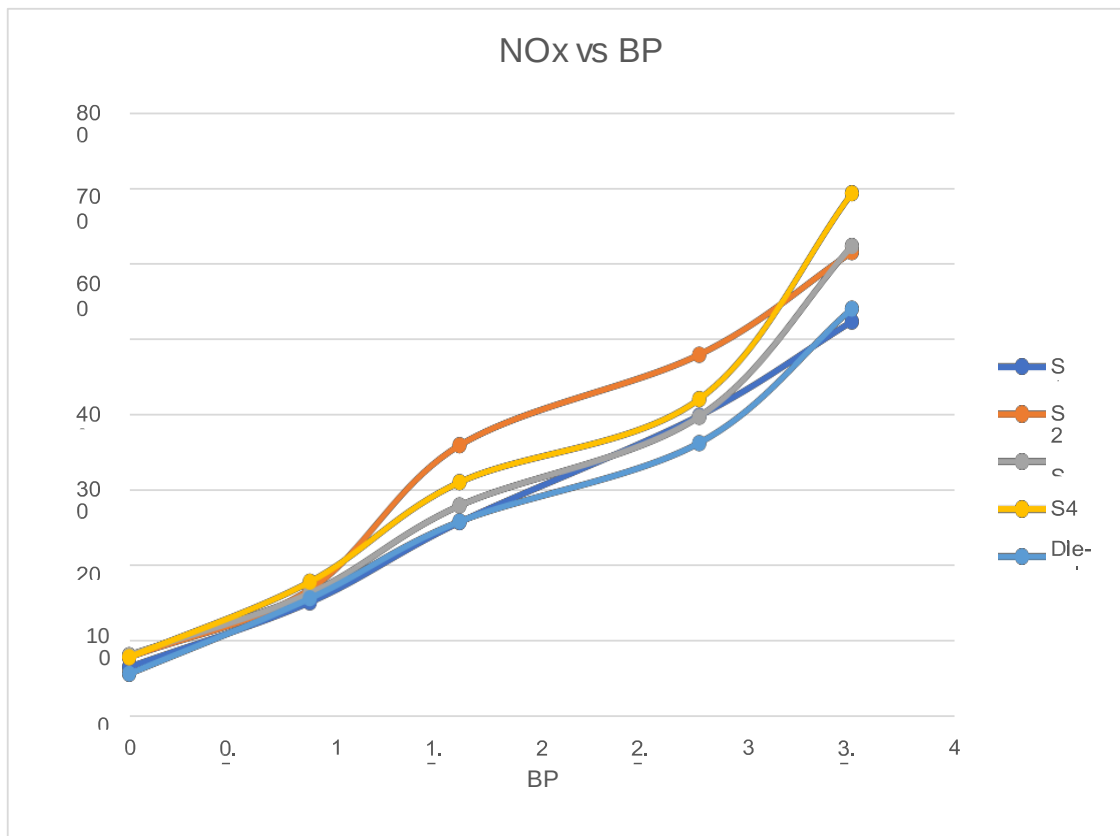


FIG 5.4: NOx Vs BP

Table 5.5: Brake Thermal Efficiency

BP	0	0.875	1.6	2.76	3.5
S1	0.64	15.49	18.36	22.02	29.63
S2	0.24	13.98	17.86	23	30.76
S3	0.23	12.13	17.98	20.12	32.54
S4	0.23	14.29	21.88	26.24	32.32
Diesel	56	156	258	362	540

From the above table.5.5, we can notice that increase in the brake thermal efficiency with an increase in the load. Higher brake thermal efficiency is seen in B15 Custard apple bio-diesel and less brake thermal efficiency is seen in Diesel. The reason for this is the high viscosity and density of Biodiesel.

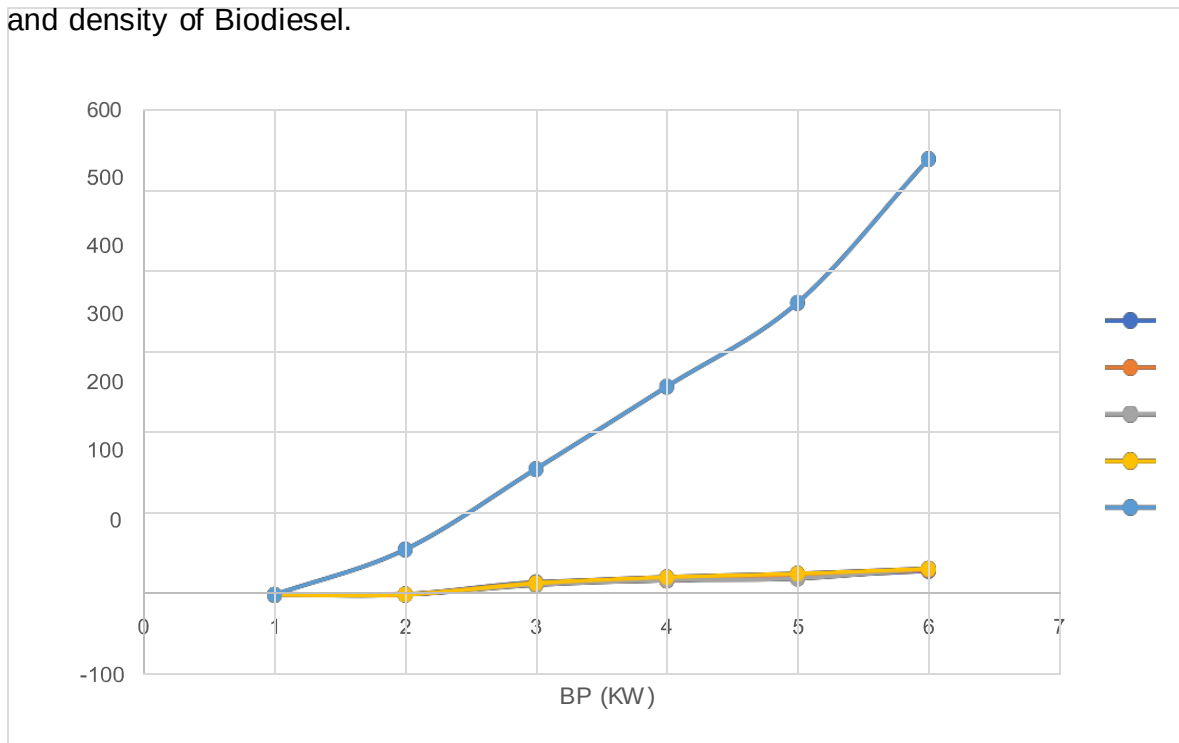


FIG 5.5: BTE Vs BP

Table 5.6: Specific Fuel Consumption

BP	0	0.875	1.6	2.76	3.5
S1	2.32	0.55	0.47	0.39	0.3
S2	3.37	0.61	0.48	0.32	0.28
S3	3.64	0.71	0.48	0.43	0.16
S4	3.21	0.6	0.48	0.42	0.2
Diesel	3.45	0.52	0.38	0.29	0.2

From the above table.5.6, we can notice that the specific fuel consumption of biodiesel is decreasing when there is increasing in the load. The lowest SFC is given by BI5 biodiesel at 100% load. B20 custard apple biodiesel also has less specific fuel consumption at 100% Load compared to pure diesel at 100% Load.

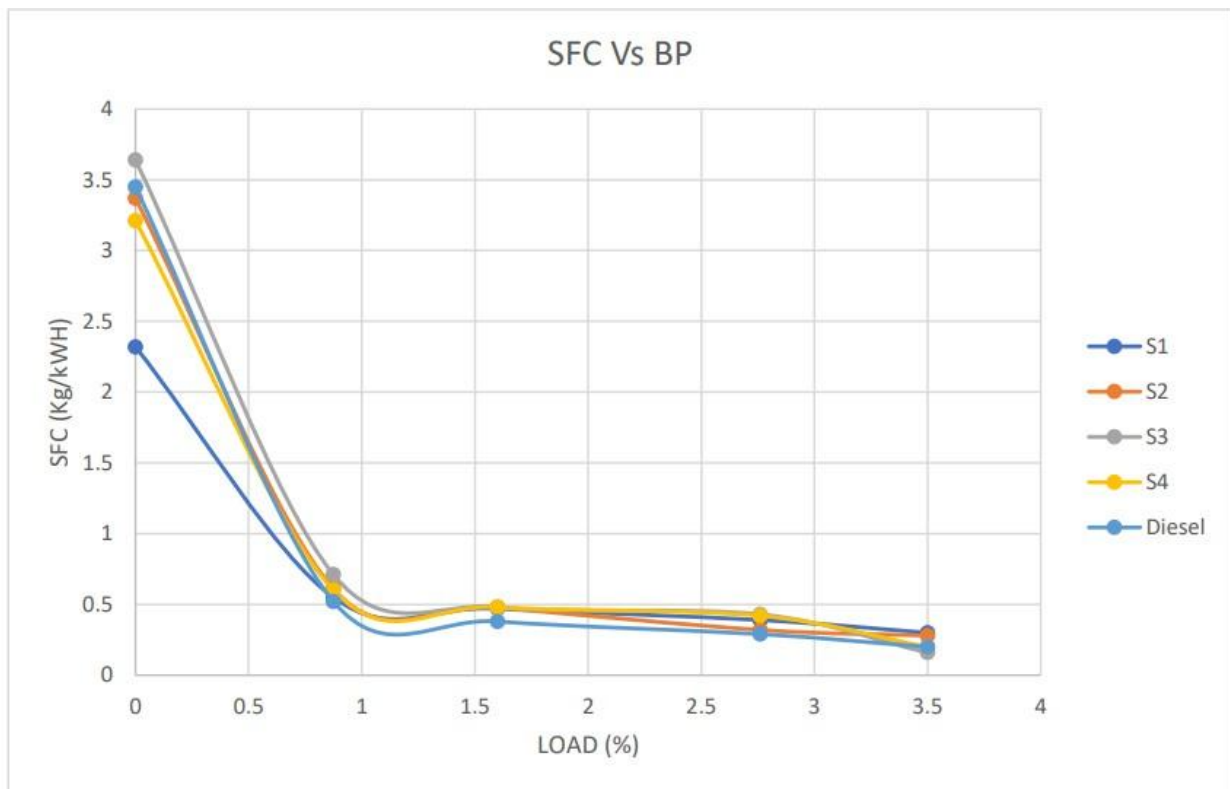


FIG 5.6: SFC Vs BP

5.7. Pressure Angle:

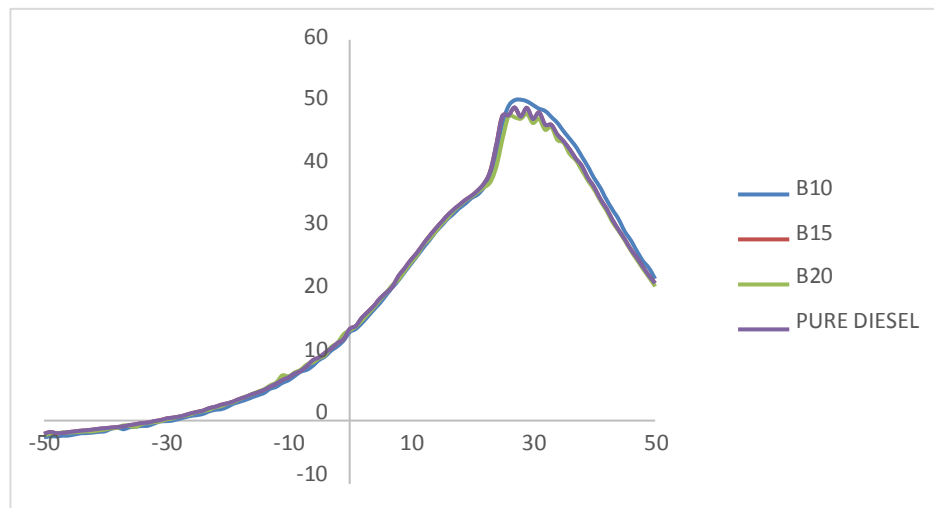


FIG 5.7: PRESSURE ANGLE

From the Above Fig.5.7 represents combustion pressure based on the crank angle of -50 to 50 in the diesel engine. In cylinder all most all blends have similar pressure value compare to pure diesel pressure value.

5.8. HEAT RELEASE RATE:

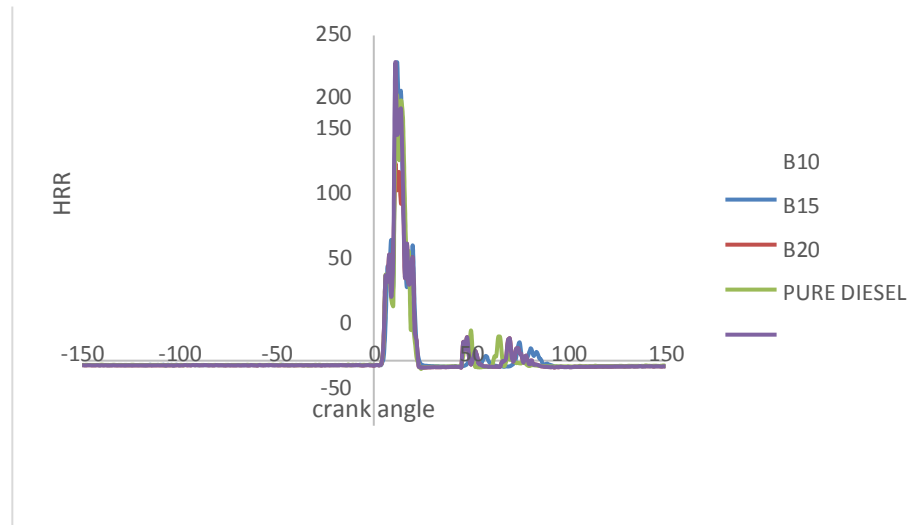


FIG 5.8: HEAT RELEASE RATE

From the Above Fig.5.8 represents heat release rate according to the crank angle of -150 to 150 in diesel engine. In this we can notice that B15 blend of biodiesel are having less heat release rate compare to heat release rate for pure diesel because biodiesel having high flame velocity than diesel.

CHAPTER 6

CONCLUSION

The results of this study showed that using quaternary blends of diesel fuel, Jatropha biodiesel can improve the environmental performance of diesel engines. The quaternary blends had lower CO, HC, and smoke emissions than diesel fuel, while their NO_x emissions were higher. However, the engine performance of the quaternary blends was slightly lower than diesel fuel, with lower BTE and higher SFC. The results suggest that further optimization of the engine parameters and the fuel blend composition is necessary to achieve better engine performance and emissions. The results of the study show that blending diesel fuel with biodiesel, ethanol, and butanol can have positive effects on engine performance, including an increase in brake power and brake thermal efficiency, as well as a decrease in brake specific fuel consumption. These benefits were observed at certain blend ratios, indicating that careful optimization of blend ratios is important for achieving the best balance between engine performance and emissions. In conclusion, the experimental investigation of the effects of biodiesel quaternary blends on engine performance and emissions has provided valuable insights into the potential benefits of using biodiesel blends in diesel engines.

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