

ANALYSIS OF THE EFFECTS OF QUATERNARY BIODIESEL BLENDS ON ENGINE PERFORMANCE AND EMISSIONS OF BIODIESEL BASED ENGINE

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

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

**Accredited with grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119.**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **JEMILSON.J (39150055)** and **AHINO SHELLY.P (39150003)** who carried out the project entitled “ **ANALYSIS OF THE EFFECTS OF QUATERNARY BIODIESEL BLEND ON ENGINE PERFORMANCE AND EMISSIONS OF BIODIESEL BASED ENGINE** ” under my supervision from December 2022 to April 2023.

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We, **JEMILSON.J** and **AHINO SHELLY.P** hereby declare that the Project Report entitled “**ANALYSIS OF THE EFFECTS OF QUATERNARY BIODIESEL BLEND ON ENGINE PERFORMANCE AND EMISSIONS OF BIODIESEL BASED ENGINE**” done by us under the guidance of **Dr. R.B. DURAIRAJ, M.Tech ., Ph.D.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering Degree in Mechanical Engineering.

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ABSTRACT

The use of fossil fuels is rising rapidly, leading to a further rise in the level of air pollution. Due to all these environmental challenges, there is a need for some innovative cleaner and environmentally viable fuels. There are waste cooking oil and various vegetable plants like karanja, neem, soyabean, etc. are used for producing biodiesel. It has been reported that use of biodiesel reduce the emission and increases the performance of engine. In most of these cases only single additives were used but to overcome this we're using multifunctional additives like curcumin, pentanol, diethyl ether. In this review we present an overview about waste cooking oil with multifunctional additives.

Keywords: Biodiesel, Multifunctional Additive, Waste Cooking Oil, Curcumin, Pentanol, Diethyl Ether.

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LIST OF ABBREVIATIONS

CO	CARBON MONOXIDE
NOX	NITROGEN OXIDES
CO ₂	CARBON DIOXIDE
HC	HYDROCARBON
NaOH	SODIUM HYDROXIDE
KOH	POTASSIUM HYDROXIDE
WCO	WASTE COOKING OIL
FFA	FREE FATTY ACIDS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
VOCs	VOLATILE ORGANIC COMPOUNDS
CP	CLOUD POINT
PP	POUR POINT
IC	INTERNAL COMBUSTION

CHAPTER 1

INTRODUCTION

Biodiesel, an alternative to traditional diesel fuel, has gained popularity due to its renewable and eco-friendly nature. As researchers strive to develop sustainable energy solutions, biodiesel has emerged as a promising option for reducing carbon emissions and mitigating climate change. However, there is still a need to improve biodiesel's properties and performance to make it a viable alternative to conventional diesel fuel. One approach to enhance biodiesel is through the use of additives such as Pentanol and Curcumin, which have demonstrated potential to enhance fuel characteristics.

Pentanol, an alcohol, and curcumin, a natural compound found in turmeric, have been explored for their ability to enhance the properties and performance of biodiesel. Pentanol has shown to reduce biodiesel viscosity and improve its combustion characteristics, while curcumin's antioxidant and anti-inflammatory properties can potentially increase the fuel's stability and oxidative resistance. While previous studies have reported the positive effects of these additives, further investigation is required to understand their impact on biodiesel fuel characteristics and performance.

This report aims to provide a comprehensive review of current literature on the impact of Pentanol and Curcumin additives in biodiesel production. We will examine the reported effects of these additives on biodiesel fuel properties, including viscosity, oxidative stability, combustion characteristics, and emissions. We will also analyze the challenges and limitations associated with the use of these additives and identify areas for future research. Through this analysis, we aim to provide a detailed understanding of the potential benefits and drawbacks of pentanol and curcumin additives in biodiesel production and to assess their effectiveness in improving biodiesel as a sustainable and eco-friendly fuel source.

The above-mentioned articles discussed the biodiesel blends with multi additive's, Most of the case studies they have used addition for one function only but there is a need to overcome such is used hence we need to discuss

multifunctional additives in order to provide specific lengths. However, very few articles were published in order to this.

1.1 PROJECT OVERVIEW

1.1.1 Waste Cooking Oil

This report will discuss the use of waste cooking oils for the production of biodiesel. The purpose of this report is to provide an overview of the benefits and challenges of using waste cooking oils for biodiesel production and to evaluate the feasibility of implementing a biodiesel project that uses waste cooking oils. Waste cooking oil (WCO) was obtained from the kitchen of the Satyabhama Institute of Science and Technology, Chennai, Tamil Nadu, India. Methanol (6:1 molar ratio to WCO) and the base catalyst Noah pellets (0.5 wt.% of WCO) was used for the transesterification process.

Waste cooking oils are generated from food processing and cooking operations in restaurants, cafeterias, and other food establishments. These oils can be collected and processed to produce biodiesel, which is a renewable alternative to petroleum diesel. Using waste cooking oils for biodiesel production has several benefits of Reducing waste and pollution: By diverting waste cooking oils from landfills or sewers, biodiesel production can help to reduce environmental pollution and Reducing dependence on fossil fuels: Biodiesel is a renewable fuel that can reduce dependence on petroleum diesel. Lowering greenhouse gas emissions Biodiesel produces fewer greenhouse gas emissions than petroleum diesel. Waste cooking oils can be obtained at a lower cost than virgin vegetable oils used for biodiesel production.

There are also several challenges associated with using waste cooking oils for biodiesel production of Waste cooking oils can be contaminated with impurities such as water, food particles, and chemicals, which can affect the quality of the biodiesel produced. The availability of waste cooking oils can be inconsistent, which can make it difficult to maintain a steady supply for biodiesel production. The cost of processing waste cooking oils into biodiesel can be higher than the cost of processing virgin vegetable oils. Using waste cooking oils for biodiesel production has several benefits, including reducing waste and pollution, reducing dependence on fossil fuels, lowering greenhouse gas emissions, and cost savings.

However, there are also several challenges associated with using waste cooking oils for biodiesel production, including quality control, availability, and processing costs. The feasibility of a biodiesel project using waste cooking oils depends on several factors, including availability, processing capacity, quality control, and cost analysis.



Figure 1.1: Waste Cooking Oil

1.1.2 Pentanol

1-Pentanol is an alcohol with five carbon atoms and the molecular formula $C_5H_{11}OH$. 1-Pentanol is a colorless liquid with a distinctive aroma. It is the straight-chain form of amyl alcohol. Pentanol(also known as amyl alcohol) is a type of alcohol that can be used as a co-solvent in biodiesel production. Biodiesel is typically produced by reacting waste cooking oil with an alcohol (such as methanol) in the presence of a catalyst. Pentanol can be added to the reaction mixture as a co-solvent to improve the solubility of the reactants and to promote better mixing and reaction.

The addition of Pentanol to biodiesel production can have several benefits of pentanol can help to increase the yield of biodiesel by improving the reaction efficiency and reducing the amount of unreacted oil and it can help to increase the yield of biodiesel by improving the reaction efficiency and reducing the amount of unreacted oil. The use of pentanol in biodiesel production can also have some drawbacks. For example, pentanol is more viscous than some other co-solvents,

which can make it more difficult to handle and mix in the reaction mixture. Additionally, the use of pentanol can affect the quality and properties of the biodiesel produced, which may require additional testing and processing.

The use of pentanol can help to reduce emissions of volatile organic compounds (VOCs) during biodiesel production. pentanol can be used as a co-solvent in biodiesel production to improve yield, reduce costs, and lower emissions. However, the specific benefits and drawbacks of using pentanol will depend on the specific conditions and requirements of the biodiesel production process. Adding pentanol as a co-solvent in biodiesel production can have several benefits, including improved yield, lower cost, reduced emissions, and improved cold flow properties.

However, there are also some drawbacks associated with its use, including viscosity, quality control, and safety. The feasibility of adding pentanol to biodiesel production will depend on several factors, including production capacity, availability of pentanol, cost analysis, and quality control.

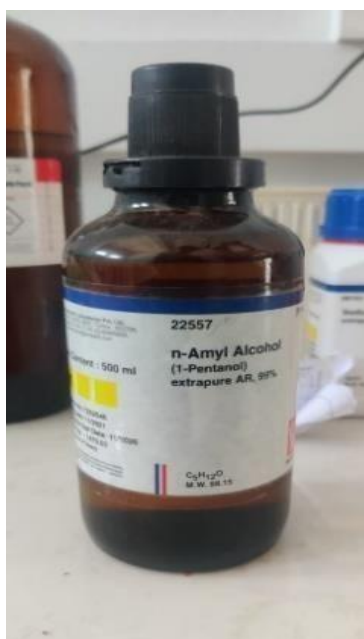


Figure 1.2: Pentanol

1.1.3 Curcumin

Curcumin is a natural compound found in turmeric, a spice commonly used in cooking. It has been studied for its potential use as an additive in biodiesel production. The purpose of this report is to provide an overview of the benefits and drawbacks of adding curcumin to biodiesel production, as well as to evaluate the

feasibility of its use. Benefits of adding curcumin to biodiesel production can improve oxidative stability. The addition of curcumin can help to improve the oxidative stability of biodiesel, which is important for its shelf life and performance. The use of curcumin can help to reduce emissions of particulate matter and other pollutants during biodiesel combustion.

Curcumin is relatively inexpensive compared to some other additives commonly used in biodiesel production, such as antioxidants. Curcumin is a natural compound derived from turmeric, which is a renewable source. The compatibility of curcumin with other additives and components in the biodiesel production process should be evaluated to ensure that it does not negatively affect the quality and properties of the biodiesel produced. Procedures for quality control should be established to ensure that the addition of curcumin does not negatively affect the quality and properties of the biodiesel produced. Adding curcumin as an additive in biodiesel production can have several benefits, including improved oxidative stability, reduced emissions, lower cost, and a renewable source.

However, there are also some drawbacks associated with its use, including compatibility, quality control, and availability. The feasibility of adding curcumin to biodiesel production will depend on several factors, including production capacity, availability of curcumin, cost analysis, and quality control.

During the biodiesel production process, curcumin can be added as an antioxidant to help prevent the formation of free radicals that can cause the fuel to degrade over time. Curcumin is a potent antioxidant that can scavenge free radicals, making it a promising additive for improving the oxidative stability of biodiesel. Curcumin also has antimicrobial properties that can help to prevent bacterial and fungal growth in the fuel during production and storage. This can reduce the risk of fuel spoilage and improve the quality of the end product. Although more research is needed to determine the optimal concentration of curcumin and its effects on the properties of biodiesel, its use as an additive shows promise for improving the stability and quality of biodiesel fuel.



Figure 1.3: Curcumin

1.1.4 Biodiesel

Biodiesel has a smaller mass energy content than diesel fuel because it contains less carbon and hydrogen. Biodiesel has a smaller volumetric energy content than other diesel because of its higher fuel density. Most biodiesel fuels have much greater viscosities. The blends were prepared using a Sartorius digital balance for preparing a small blends of a given liquid. Conventionally, biodiesel fuel blends can be made by utilising acid or alkali as a catalyst. Transesterification is the process by which methanol reacts with animal or vegetable fat to produce esters and glycerol. Either of the two types of monohydric aliphatic methanol is used to carry out the transesterification reaction. It is possible to conduct the reaction at room temperature.

CHAPTER 2

LITERATURE SURVEY

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

The study by Rizwanul 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. The authors noted that pentanol can improve the

solubility and reaction rate of reactants, leading to higher biodiesel yields and better product quality. However, the cost-effectiveness of using pentanol as a co-solvent needs to be evaluated in relation to other co-solvent options.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of producing biodiesel from waste cooking oil is to provide a sustainable alternative to traditional fossil fuels that are contributing to environmental degradation and climate change. Biodiesel made from waste cooking oil has several benefits, including reducing greenhouse gas emissions, reducing dependence on fossil fuels, and reducing waste. It improves energy security. The use of biodiesel reduces dependence on foreign oil imports and helps to ensure a reliable supply of fuel and create economic opportunities: The production of biodiesel from waste cooking oil can create job opportunities and stimulate economic growth, particularly in rural areas. It reduces pollution and biodiesel emits fewer harmful pollutants such as particulate matter and carbon monoxide compared to traditional fossil fuels, which can improve air quality and public health. Waste cooking oil reduces greenhouse gas emissions by up to 80% compared to traditional fossil fuels, which can help to mitigate the effects of climate change. By utilizing waste cooking oil as a feedstock for biodiesel production, it encourages waste reduction and creates a more circular economy. Biodiesel production from waste cooking oil reduces dependence on non-renewable energy sources and enhances energy independence. This is especially important for countries that rely heavily on oil imports, as it can reduce the impact of fluctuating oil prices and supply disruptions. Biodiesel production from waste cooking oil reduces dependence on non-renewable energy sources and enhances energy independence. This is especially important for countries that rely heavily on oil imports, as it can reduce the impact of fluctuating oil prices and supply disruptions.

3.2 SCOPE

The feedstock for biodiesel production from waste cooking oil is waste cooking oil, which is generated from various sources such as households, restaurants, and food processing industries. The quality of the feedstock can vary depending on the source, and it is important to ensure that the oil is free of contaminants and meets the necessary specifications for biodiesel production. The production process for biodiesel from waste cooking oil involves several steps,

including pre-treatment, transesterification, and purification. Pre-treatment involves removing any impurities and contaminants from the feedstock, such as water and free fatty acids. Transesterification involves reacting the feedstock with an alcohol, typically methanol, in the presence of a catalyst to produce biodiesel and glycerine. The biodiesel is then purified to remove any remaining impurities and contaminants.

Biodiesel from waste cooking oil has a significant market potential, as it can be used as a substitute for traditional fossil fuels in various industries such as transportation, agriculture, and power generation. It can also be blended with traditional diesel fuel to improve its properties and reduce emissions. waste cooking oil has several environmental benefits, including reduced greenhouse gas emissions, improved air quality, and reduced landfill waste. These benefits can help to mitigate the impact of climate change and promote a more sustainable future. Biodiesel production from waste cooking oil can create economic opportunities by generating new jobs and stimulating economic growth, particularly in rural areas.

It can also reduce the dependence on foreign oil imports and help to ensure a reliable supply of fuel. There is ongoing research and development in the field of biodiesel production from waste cooking oil, which aims to improve the efficiency and sustainability of the production process. This includes the development of new technologies and processes, as well as the exploration of alternative feedstocks. Overall, the scope of biodiesel production from waste cooking oil is broad and has the potential to make a significant contribution to sustainability efforts, economic growth, and energy security. With ongoing research and development, it is likely that the production process will continue to improve, making biodiesel from waste cooking oil an increasingly attractive and viable option for the future.

CHAPTER 4

METHODOLOGY

4.1 DESCRIPTION

A clear, light-to-dark yellow liquid is biodiesel. It contains a low vapor pressure and high boiling point, and it is essentially immiscible with water. The flash point of typical methyl ester biodiesel is at 150 °C (300 °F), making it relatively inflammable. The density of biodiesel is 0.88 g/cm³, which is lower than the density of water. It is possible to classify uncontaminated biodiesel as non-toxic. Curcumin and pentanol are two additives that can be used in biodiesel to improve their properties. Curcumin is a natural pigment found in turmeric; a spice commonly used in Indian cuisine. It is known for its antioxidant and anti-inflammatory properties. In biodiesel, curcumin can act as an antioxidant and prevent the oxidation of the fuel, which can lead to the formation of harmful compounds and reduce the fuel's stability.

Pentanol, on the other hand, is an alcohol that can be used as a co-solvent in biodiesel. It can improve the solubility of the fuel and reduce its viscosity, making it easier to use in diesel engines. Pentanol can also act as a lubricant, reducing wear and tear on engine components. Both curcumin and pentanol are natural compounds that can be added to biodiesel without the use of harmful chemicals. Their use can improve the performance and stability of biodiesel, making it a more viable alternative to traditional diesel fuel. However, further research is needed to fully understand the effects of these additives on biodiesel and their long-term sustainability. In addition to curcumin and pentanol, there are other additives that can be used in biodiesel to improve its properties. For example, antioxidants such as butylated hydroxytoluene (BHT) and tocopherols can be added to prevent oxidation of the fuel. This can help to increase the shelf life of the fuel and reduce the formation of harmful compounds. Both curcumin and pentanol are natural compounds that can be added to biodiesel without the use of harmful chemicals. Their use can improve the performance and stability of biodiesel, making it a more viable alternative to traditional diesel fuel.

4.2 WASTE COOKING OIL

Waste Cooking Oil, Methanol, Sodium Hydroxide, Pentanol, Curcumin and Diesel (Shell) was used for the current work. Waste cooking oil (WCO) was obtained from the kitchen of Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India. Methanol($350 \times 0.3 = 105$ ml) and the base catalyst Noah pellets (3.5 g) were used for the transesterification process.

- Pour 105 millilitres methanol into the glass blender pitcher.
- Turn the blender on its lowest setting and slowly add 3.5 grams sodium hydroxide (lye). This reaction produces sodium methoxide, which must be used right away or else it loses its effectiveness.
- Mix the methanol and sodium hydroxide until the sodium hydroxide has completely dissolved

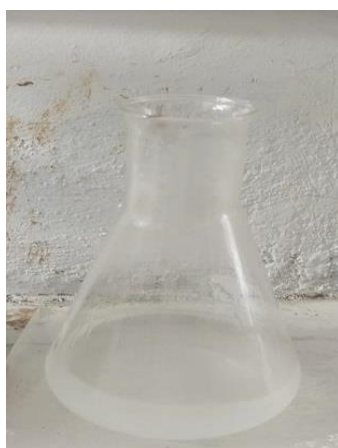


Figure 4.1: Methanol Dissolved With NaOH

- Heat the 350 ml of oil until it reached 60 °C. Turn off heat



Figure 4.2: Heated Oil

- Add the sodium hydroxide methanol mixture into the oil, Continue blending this mixture (on low speed) for 20 to 30 minutes.



Figure 4.3: Solution With WCO

- After stirring let the mixture leave for 24 hours



Figure 4.4: Mixed Solution

- You will see the liquid start to separate out into layers.



Figure 4.5: Separation Of Oil

- After 24 hours decant to separate the biodiesel from glycerol, The bottom layer will be glycerin. The top layer is biodiesel.



Figure 4.6: Separation Of Glycerin With Oil

- Separate the Biodiesel alone without glycerin



Figure 4.7: Separation Of Biodiesel

- Add the distilled water in the biodiesel. Mix it well and pour it in to separating funnel .It will separate in to biodiesel from impurities.



Figure 4.8: Distilled Water Washing

- Repeat this process three to four times to remove excess contaminants and leftover production chemicals from biodiesel. Finally, filter the biodiesel by using filter paper.



Figure 4.9: Waste Cooking Biodiesel

4.3 BIODIESEL

4.3.1 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.

4.3.2 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.

4.4 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.

4.4.1 Copper Corrosion Measurement

The copper corrosion test aims to investigate the influence of fuels and its fuel blends on copper's corrosion behavior. The copper specimen as shown in figure is polished with silicon carbide abrasive papers. The fuel was poured into the container and the copper specimen was made to hang inside the container. The reaction took place for three hours and the corrosion behavior of the fuel sample was investigated. The reaction was compared with the standard data. The same test was carried on for other blends, the corrosion behavior was noted, and results are tabulated.



Figure 4.10: Copper Corrosion Equipment

4.4.2 Density Measurement

The density of high-performance fuel and its blends were measured using a device called hydrometer. The hydrometer is a device that is used to find out the specific gravity with an accuracy of 0.01. Initially 250ml of biodiesel was poured into a beaker and a hydrometer with a suitable specific gravity range was selected. After selection, the hydrometer was immersed into the beaker and the stabilization process took place. On by immersion, the specific gravity value was displayed on the graduated scale of the hydrometer device. The same procedure was carried out for the remaining biofuel blends as well.



Figure 4.11: Hydrometer

4.4.3 Viscometer Measurement

The kinematics viscosity was measured by using a device called Canon-Fenske viscometer, the viscosity tube was first cleaned and rinsed using acetone solution and dried up. 50 ml of high-performance fuel blend was poured into the viscosity tube. This is achieved by placing the tube's thinner arm into a beaker filled with high performance. After placing, suction force was used to draw up the diesel to the upper mark of the viscometer. The viscometer was placed inside a constant temperature bath with the help of a holder and set at a desired temperature of 40°C for a duration of 30 minutes for the high-performance sample to come to the bath temperature. The high performance sample was drawn slightly above the upper mark by applying a suction force on the thinner arm. The time was recorded by

timing the flow of the sample as it flowed freely from the upper mark to the lower mark. The same procedure was carried out for remaining high-performance.



Figure 4.12: Canon-Fenske Viscometer

4.4.4 Calorific Value

The calorific value was determined using a bomb calorimeter, this was achieved by measuring the amount of heat generated when high-performance of 10ml was burnt in a closed chamber. This apparatus comprises of bomb, bomb firing unit, illuminator with magnifier, offset stirrer, calorimeter vessel, gas release valve, water jacket, pellet press vibrator, timer, pressure gauge, crucible, and ignition wire.



Figure 4.13: Bomb Calorimeter

4.4.5 Flash and Fire Point Apparatus

Flash point and fire point of fuels in the temperature range from 40°C to 370°C can be measured by using a manual Pinsky-Martens closed-cup apparatus. In this test, about 200 ml of high-performance is poured into a brass cup which is then fit with a cover. The sample is heated and stirred steadily. An ignition source (fire) is introduced into the cup at regular intervals while simultaneously stirring until it reaches a temperature at which the volatile material ignites, and a flash is produced that spreads evenly throughout the inside of the cup. This temperature was recorded as flash point. On further heating and stirring, an ignition source was introduced at regular intervals until it reaches a temperature where vapors are produced at a rate to sustain the fire for at least 5 seconds. This temperature was noted down as the fire point. The same procedure was carried out for other high performance blends.

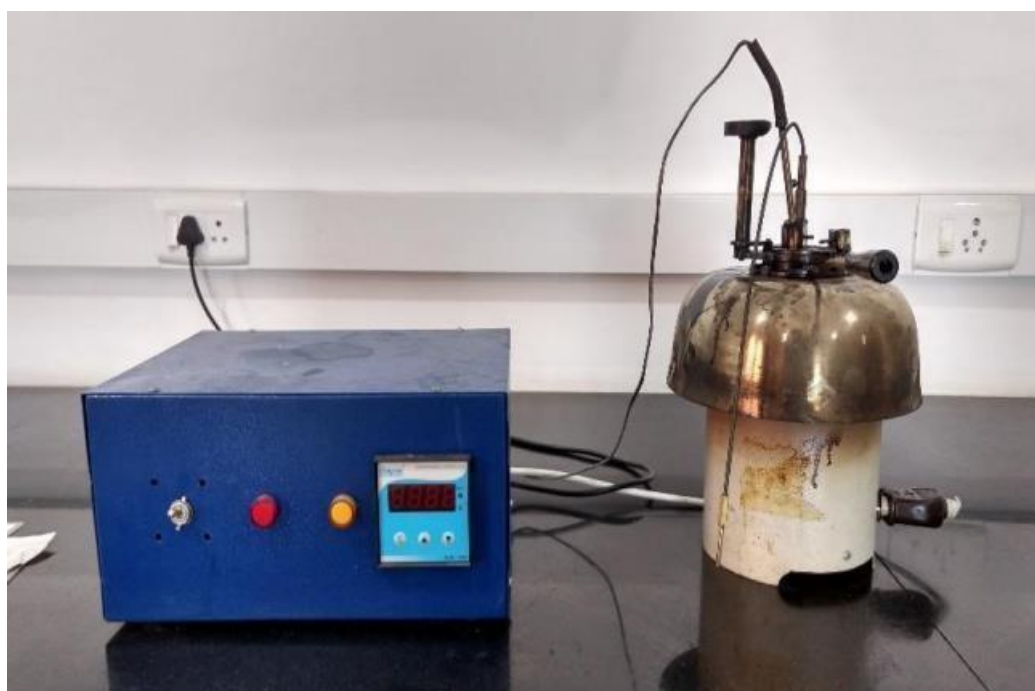


Figure 4.14: Pinsky-Martens Closed-Cup Apparatus

4.4.6 Cloud And Pour Point Measurement

Cloud Point (CP) and Pour Point (PP) values were measured according to ASTM D97-17 standards. The high-performance were poured into a glass test tube and cooled under given conditions and was inspected at intervals of 1°C until tiny wax crystals were formed, giving rise to a cloudy structure. This temperature was noted down as CP. The high-performance sample was further cooled in a glass tube and observed at intervals of 3°C until the sample completely lost its fluidity even when it was tilted. The PP is noted as 3°C above the temperature at which the sample lost its fluidity.



Figure 4.15: Cloud And Pour Point Machine

CHAPTER 5

EXPERIMENTAL SETUP

5.1 DIESEL ENGINE

An internal combustion (IC) engine, the diesel engine ignites the fuel after it has been introduced into the combustion chamber at a high temp that petrol reaches when it is considerably compressed. Unlike spark-ignition engines, like gasoline engines or gas engines, which ignite an air-fuel mixture using a spark plug. A diesel engine has the greatest thermal effectiveness of any imaginable internal or external combustion engine due to its enormous growing proportion and inherent lean burn, which encourages heat dissipation through the excess air. Diesel motors with two and four strokes are both made. In this experiment, a four-stroke diesel engine is being used. The piston completes four different strokes while the crankshaft revolves in a four-stroke engine, a kind of internal combustion (IC) engine. A piston's whole motion along the cylinder, whether in one direction or the other, is known stroke. he four different strokes are referred to as:

- Intake: The intake stroke of a diesel engine begins with the piston moving downward, which creates a vacuum in the cylinder. This vacuum draws in air through the intake valve.
- Compression: Once the air is drawn into the cylinder, the piston moves upward, compressing the air. This compression raises the temperature of the air to a point where it can ignite the fuel.
- Combustion: Fuel is delivered into the cylinder just as the engine's piston reaches the peak of its stroke. Gases quickly expand as a result of the fuel being ignited by the heat produced by the compressed air. By pushing the piston downward, this expansion generates power. 17
- Exhaust: As the piston moves downward, it pushes the exhaust gases out of the cylinder through the exhaust valve. The cycle then repeats itself, with the piston moving upward to begin the intake stroke again.



Figure 5.1: Engine Setup

From Figure 5.1 we evaluate that, An eddy current dynamometer is connected to a single- cylinder, four-stroke diesel engine with an electronic start and a variable compression ratio for loading. The compression ratio can be changed utilising a specially designed tilted cylinder block arrangement without shutting down the engine or changing the geometry of the combustion chamber. The system is equipped with the instruments needed to measure combustion pressure and crank angle. The signals in question are connected to the computer for PPV diagrams via the engine indicator. There is also space for the interface of temperature, fuel flow, airflow, and load monitoring

Table 5.1: 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

5.2 EXHAUST GAS ANALYZER

Please follow these instructions to transfer readings from a petrol analyzer to ADCS Software.

- Kindly fill the details (Engine Number Model and Engine Type) in the given form.
- Press Connect button to connect the computer with equipment and then see for 2 to 3 minutes. If The results are not coming it shows the message in red colour “CO HC power not communicating.” kindly see the following below :
- Be sure that gas analyzer settings in “MAHA Euro” mode
- Check the COM port settings with PC and the software.
- RS232 Cable is working properly and connected with equipment.
- Readings are coming with equipment and display on panel.
- After six seconds results are usually saved in database and status bar strip moving according to result saved in database.
- After taken readings click on “Disconnect button” it disconnect the

communication with equipment and show the message “Data Saved in Database”.

- Report: Click on report button to take the report of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel Sheet: To export data in excel sheet click on “EXPORT TO EXCEL” button. When pressing export button a excel file is generated in a path “C:\ AVLFolder”.

The file name of excel file is same as Test Date and VIN no (Tuesday, January06, 2009_23).

- Close button : click on close button to exit from current active window or screen.



Figure 5.2: Exhaust Gas Analyzer

Table 5.2: Exhaust Gas Analyzer Specification

Manufacturer	SMS Autoline Equipments 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 % Nitrousoxides -1 PPM
Principle	Carbon monoxide -NDIR Carbon dioxide -NDIR Hydrocarbon -NDIR Oxygen -Electrochemical Nitrousoxides -Electrochemical

5.3 SMOKEMETER

Please follow these instructions to transfer readings from the smokemeter to the ADCS software.

- Please enter the information (Engine Number. Model, Engine Type) in the appropriate field.
- spaces provided on the Master data entry form, all of the textboxes pertaining to (Engine Number. Type, Type Of engine, and Engine Speed) become inactive if the "Vehicle details" check box is not checked.
- Click on "Connect button "to connect the PC with equipment and wait for 5- 10 seconds. if
- the readings are not coming it show the message in red color ""Unable to Communicate with Equipment."" kindly check the following:

- Be sure that Smoke meter model name display on screen is same as your smoke meter model if not kindly change the model in “Master Data Entry Form”
 - Check the COM port settings with PC and the software in “Master Data Entry “form.
 - RS232 Cable for smoke meter is working properly and connected with equipment.
 - Readings are coming with equipment and display on remote of smoke meter.
- According to “Time interval settings in selection box, readings are automatically saves in database.
- After taking the readings click on “Disconnect button” it disconnect the communication equipment and show the message
“Disconnected”
- Report: Click on report button to take the report of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel Sheet: To export data in excel sheet click on “EXPORT TO EXCEL”
- Button. When pressing the export button a excel file is generated at path “C:\ AVLFolder\”.
- file name of excel file is same as Test Date and VIN no (Tuesday, January 06, 2009_26).
- Close button: click on close button to exit from current active window or screen, it takes time to close, so wait for 10-15 seconds for form window to close.



Figure 5.3: SMOKEMETER

Table 5.3: Smoke meter specification

Types	AVL437 Smokemeter
Make	Mars Technologies inc
range	0-100 HSU
Temperature of smoke	2500 C(degrees)
Ambient Temperature	0-50°C
Humidity	90% during 50°C
Power	5 Amperes, 11.5-36 Volts Direct current
Working Principle	LAP(Light absorption principle)

CHAPTER 6

RESULT AND DISCUSSION

6.1 PROPERTIES OF WASTE COOKING OIL BIODIESEL

Table 6.1: Properties of Waste Cooking Oil Biodiesel

 SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY (Deemed to be University) CENTRE FOR WASTE MANAGEMENT CENTRE OF EXCELLENCE FOR ENERGY RESEARCH Rajiv Gandhi Road, Jeppiaar Nagar, Sozhinganallur, Chennai - 600119 Phone : 044-24503065 / 044-24503814 / 044-24502323 E-mail: deanoffice@sathyabama.ac.in head@centreforwastemanagement.com, energyresearch@sathyabama.ac.in Website: www.sathyabama.ac.in, www.centreforwastemanagement.com, www.energyresearch.in		
Date: 27/03/2023		
To Mr. Ahnoshelly P & Mr. Jemilson J Department of Mechanical Engineering Sathyabama Institute of Science and Technology 600119		
REPORT Properties of Waste Cooking oil biodiesel		
S.No	Parameters	Results
1	Kinematic Viscosity @ 40°C	2.65
2	Calorific value	39.5 MJ/kg
3	Density	0.88
4	Flash point by PMCC method	130°C
5	Fire point by PMCC method	150°C
6	acid value	0.25
7	cloud point	5°C
8	pour point	0°C
9	copper strip corrosion	1A



Sathyabama University
Center of Excellence for Energy Research
Ministry HRD (India) Funded Centre

Chromatogram Info:

File Name	: C:\YLCarity\WORK1\DATA\NIRMAL\SAMPLES DATA\ M WCO BD 1.PRM	File Created	: 4/17/2023 1:15:20 PM
Origin	: Acquired, Acquisition started 4/17/2023 12:30:13 PM	Acquired Date	: 4/17/2023 1:15:20 PM
Project	: c:\YLCarity\Projects\Work1.PRJ	By	: Administrator

Sample Info:

Sample ID	: M WCO BD 1	Amount	: 0
Sample	: sample	ISTD Amount	: 0
Inj. Volume [mL]	: 0.2	Dilution	: 0.1

Method	: C:\YLCarity\WORK1\DATA\NIRMAL\SAMPLES DATA\FID METHODS\FAME method-2	By	: Administrator
Description	:		
Created	: 3/17/2018 9:53 AM	Modified	: 4/17/2023 1:22 PM

Column	:	Detection	:
Mobile Phase	:	Temperature	:
Flow Rate	:	Pressure	:
Note	:		

Autostop	: 45.00 min	External Start	: Start - Restart, Down
Detector 1	: Detector 1	Range 1	: Bipolar, 2500000 mV, 20 Samp. per Sec.
Subtraction Chromatogram	: (None)	Matching	: No Change

Base	: Not Used	Calibration File	: None	Calculation	: Uncal
Scale Factor	: Not Used	Units After Scaling	: Not Used	Uncal. Response	: 0
Unretained Time	: 0.00 min	Column Length	: 50.00 mm	Column Calc.	: From Width at 50% of Height
Result Table Reports	: All Peaks	Hide ISTD Peak	: Enabled		

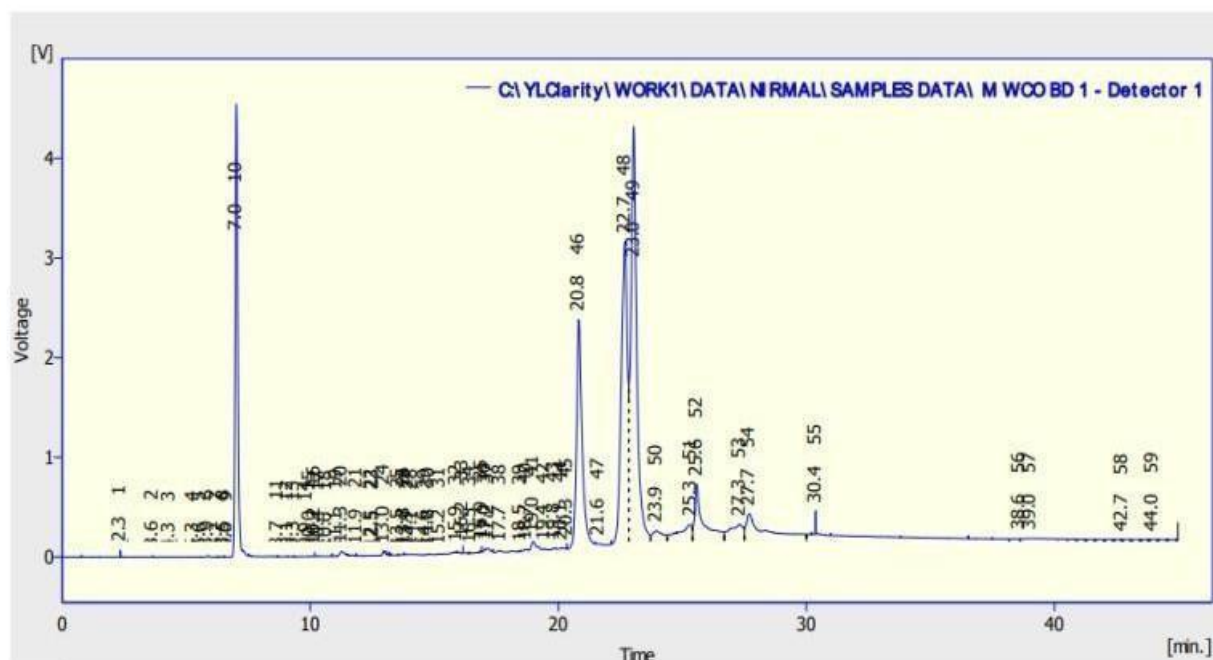


Figure 6.1: GC/FID (Gas Chromatography-Flame Ionization Detection)

Table 6.2: Gas Chromatography-Flame Ionization Detection Tabulation

Chromatogram C:\YLClarity\WORK1\DATA\NIRMAL\SAMPLES DATA\ M WCO BD 1.PRM

Result Table (Uncal - C:\YLClarity\WORK1\DATA\NIRMAL\SAMPLES DATA\ M WCO BD 1 - Detector 1)

	Reten. Time [min]	Area [mV.s]	Height [mV]	Area [%]	Height [%]	Compound Name
1	2.340	26.762	67.577	0.0	0.4	
2	3.650	4.813	11.474	0.0	0.1	
3	4.330	3.025	0.298	0.0	0.0	
4	5.267	7.257	1.788	0.0	0.0	
5	5.567	3.234	3.038	0.0	0.0	
6	5.873	61.005	11.261	0.0	0.1	
7	6.243	5.588	6.935	0.0	0.0	
8	6.523	9.537	11.181	0.0	0.1	
9	6.633	3.368	0.384	0.0	0.0	
10	7.020	34406.811	4544.916	10.2	25.9	
11	8.673	82.970	9.798	0.0	0.1	
12	9.090	15.549	7.021	0.0	0.0	
13	9.340	3.174	6.109	0.0	0.0	
14	9.853	1.229	1.134	0.0	0.0	
15	9.990	4.627	5.748	0.0	0.0	
16	10.183	23.231	40.330	0.0	0.2	
17	10.350	16.309	4.674	0.0	0.0	
18	10.637	6.147	0.477	0.0	0.0	
19	11.053	2.816	6.280	0.0	0.0	
20	11.270	741.884	47.036	0.2	0.3	
21	11.850	20.921	25.204	0.0	0.1	
22	12.460	15.676	2.627	0.0	0.0	
23	12.530	22.814	2.209	0.0	0.0	
24	12.967	461.474	48.457	0.1	0.3	
25	13.537	32.097	11.208	0.0	0.1	
26	13.787	78.186	24.917	0.0	0.1	
27	13.923	84.177	7.231	0.0	0.0	
28	14.093	123.560	6.381	0.0	0.0	
29	14.623	1.051	1.525	0.0	0.0	
30	14.773	70.110	7.022	0.0	0.0	
31	15.207	86.978	8.341	0.0	0.0	
32	15.893	544.086	38.293	0.2	0.2	
33	16.153	137.895	81.923	0.0	0.5	
34	16.453	53.436	18.883	0.0	0.1	
35	16.913	358.887	70.011	0.1	0.4	
36	17.047	363.901	51.157	0.1	0.3	
37	17.170	665.233	51.061	0.2	0.3	
38	17.660	484.735	27.483	0.1	0.2	
39	18.473	569.299	30.581	0.2	0.2	
40	18.697	524.923	35.655	0.2	0.2	
41	18.980	1975.566	109.712	0.6	0.6	
42	19.427	395.089	36.825	0.1	0.2	
43	19.820	817.351	42.021	0.2	0.2	
44	20.133	567.369	41.671	0.2	0.2	
45	20.343	316.143	81.824	0.1	0.5	
46	20.827	38983.122	2331.781	11.6	13.3	
47	21.627	1462.251	74.119	0.4	0.4	
48	22.687	55532.284	3104.848	16.5	17.7	
49	23.043	73573.515	4257.609	21.8	24.2	
50	23.947	6843.716	194.565	2.0	1.1	
51	25.347	11600.450	248.066	3.4	1.4	
52	25.577	20239.919	656.696	6.0	3.7	
53	27.317	9919.181	241.915	2.9	1.4	
54	27.697	25991.261	348.046	7.7	2.0	
55	30.373	39620.392	362.484	11.8	2.1	
56	38.600	1059.845	41.716	0.3	0.2	
57	39.020	6970.011	42.597	2.1	0.2	
58	42.730	692.427	13.924	0.2	0.1	
59	43.953	295.952	12.669	0.1	0.1	
	Total	336984.619	17580.716	100.0	100.0	

6.2 PURE DIESEL READING

The readings are taken from the single cylinder 2 stroke engine under the running speed of 1500 revolutions per minute and Brake Power 3.5 KW, injection Pressure 200 Bar. The readings are taken in pure diesel.

Table 6.3: Base Reading Tabulation

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

6.3 BIODIESEL BLEND 40% READING

The readings are taken in the (diesel 60% + WCO 40%).

Table 6.4: BLENDING 40% TABULATION

BLEND	CO	HC	CO2	O2	NOX
S1	0.007	3	0.25	20.3	37
	0.009	5	0.45	19.9	125
	0.012	7	0.8	19.7	198
	0.015	9	1.05	19.42	287
	0.017	11	1.2	19.1	364

6.4 BIODIESEL BLEND 40% WITH PENTANOL READING

The readings are taken in the (diesel 60% + WCO 30%+10% pentanol)

Table 6.5: Blending 40% With Pentanol Tabulation

BLEND	CO	HC	CO2	O2	NOX
S2	0.006	2	0.3	20.1	32
	0.008	4	0.7	19.83	98
	0.01	5	0.9	20.6	193
	0.013	7	1.2	19.9	269
	0.015	9	1.3	19.4	341

6.5 BIODIESEL BLEND 40% WITH PENTANOL AND CURCUMIN

The readings are taken in the (diesel 60% + WCO 30%+10% pentanol +0.075g curcumin)

Table 6.6: Blending 40% With Pentanol And Curcumin Tabulation

BLEND	CO	HC	CO2	O2	NOX
S3	0.01	4	0.6	20.1	54
	0.013	6	0.8	19.92	105
	0.015	8	1.2	19.6	204
	0.018	11	1.7	19.1	310
	0.023	14	2.1	18.67	450

6.6 BRAKE THERMAL EFFICIENCY**Table 6.7: BTE Tabulation**

Sample/BP(kw)	0.875	1.75	2.62	3.5
S1	13.4	21.4	27.8	30.1
S2	14.6	21.9	28.2	30.96
S3	15.8	22.3	28.9	32.17
Diesel	16.49	22.75	29.47	32.59

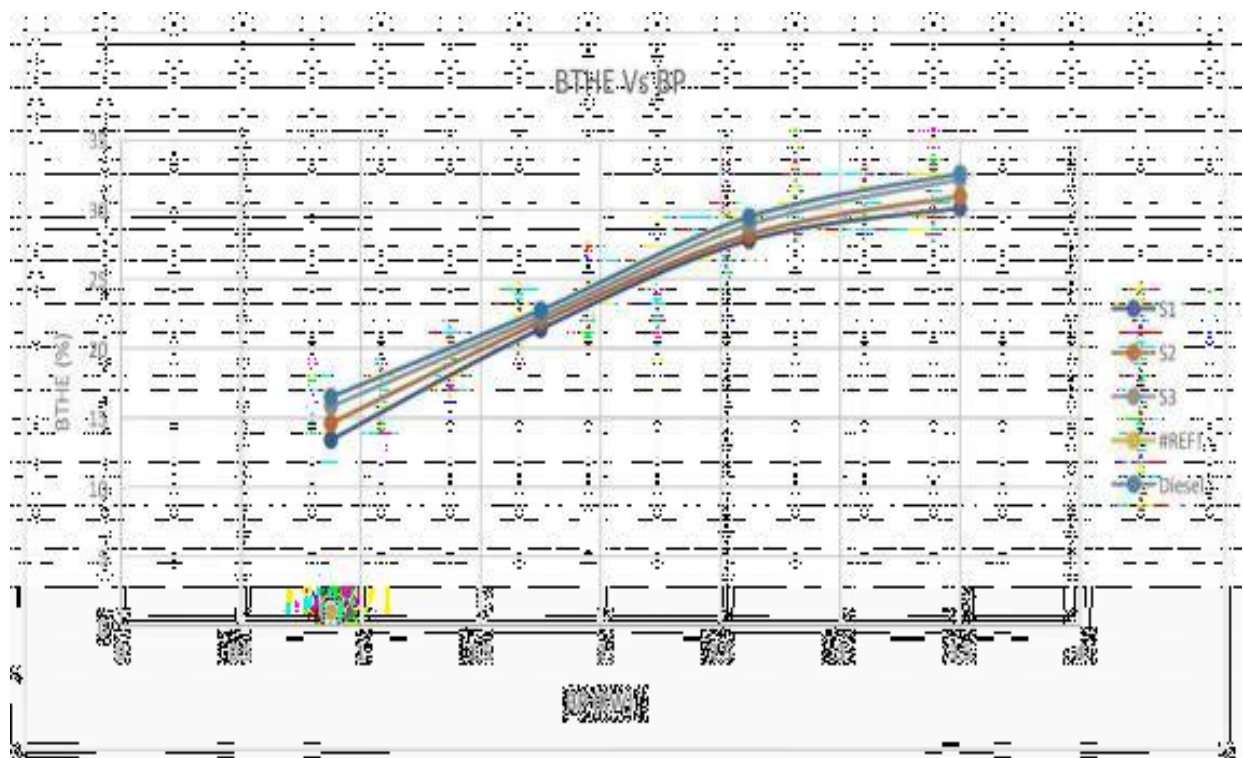


Figure 6.3: Brake thermal efficiency Vs Brake power

Figure 6.3 illustrates that all biodiesel blends have characteristics that affect their braking thermal efficiency, both lower and higher. This might be a result of biodiesel's higher viscosity and lower calorie content compared to diesel. 75D25NO50HA, which contains 30% WCO and 10% of Pentanol and 0.075g of curcumin and 60% diesel, achieves the highest brake thermal effectiveness of any biodiesel blend. Engine speeds ranging from 500 to 1500 rpm were used to examine the impact of brake thermal efficiency.

6.7 SPECIFIC FUEL CONSUMPTION

Table 6.8: Specific Fuel Consumption

Sample/BP(kw)	0	0.875	1.75	2.62	3.5
S1	2.12	0.8	0.68	0.39	0.19
S2	2.5	0.75	0.62	0.34	0.16
S3	2.38	0.71	0.59	0.29	0.12
Diesel	3.45	0.52	0.38	0.29	0.2

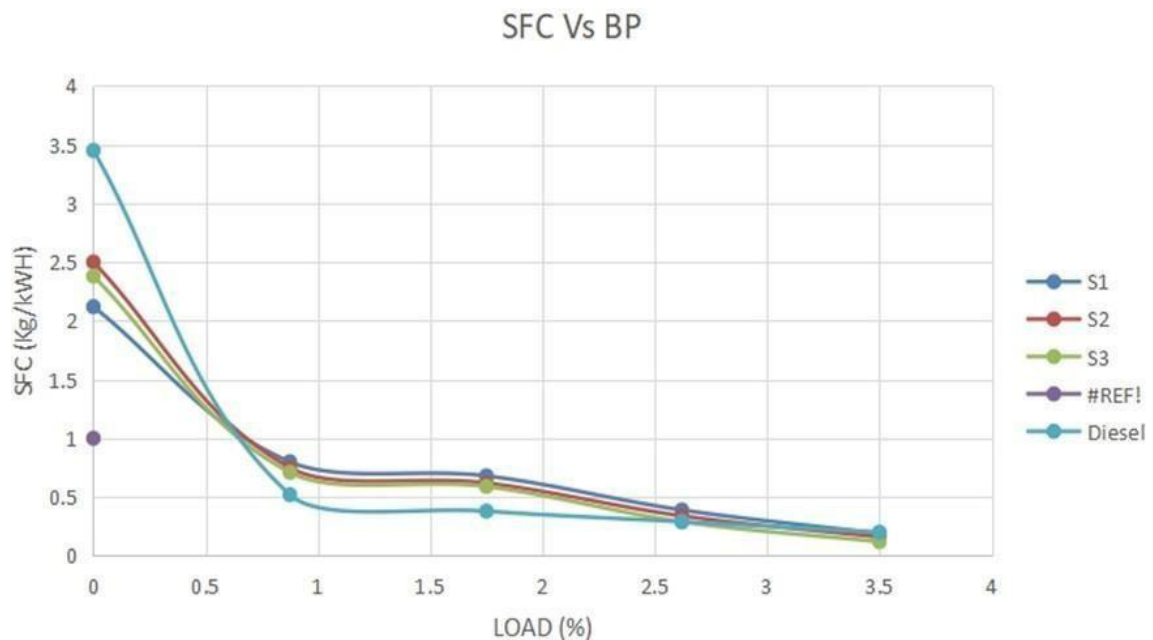


Figure 6.4: Specific fuel consumption Vs Brake power

The amount of fuel used at 3.5KW had increased due to an increase in engine load. A low calorific value is indicated by an increase in fuel usage. Further research was done at 1500 rpm since the small Specific Fuel Consumption there indicated complete fuel combustion. The greatest specific fuel consumption of all the biodiesel blends is found in 75D25NO50HA, which contains 30% WCO and 10% of Pentanol and 0.075g of curcumin and 60% diesel, The smallest specific fuel consumption is found in 90D10NO50HA, which includes 30% WCO biofuel and 60% diesel and 0.075g curcumin with 0.19 kg/KWH. There are 0.16kg/KWH and 0.12kg/KWH in the

blends 80D20NO50HA and 85D15NO50HA, respectively. This might be the case because the mixtures burn more efficiently compared to other biodiesel blends since they have more energy.

6.8 HYDROCARBON EMISSION

Table 6.9: Hydrocarbon emission

Sample/BP(kw)	0	0.875	1.75	2.62	3.5
S1	3	5	7	9	11
S2	2	4	5	7	9
S3	4	6	8	11	14
Diesel	2	6	10	15	19

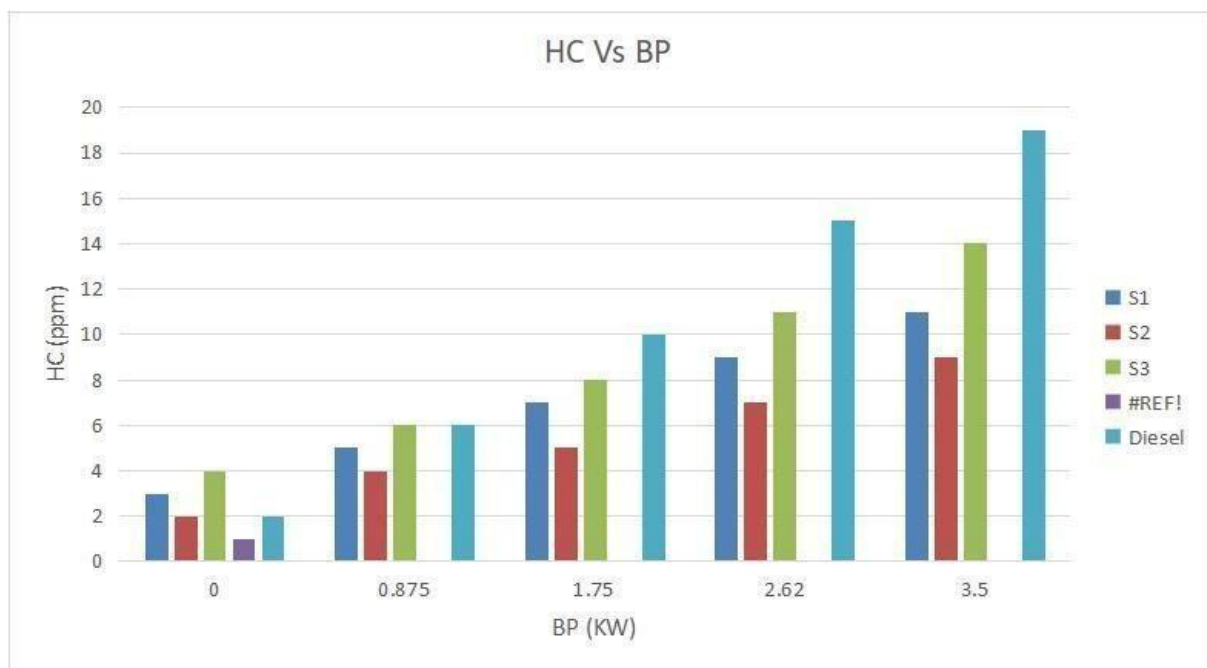


Figure 6.4: Hydrocarbon emission Vs Brake power

The highest HC emission (19ppm), whereas 90D10NO50HA has the lowest (11 ppm) HC emission. This is due to the blend's higher volatility, which produces more efficient combustion relative to other blends of biodiesel. The speed at which air and fuel mix have a big impact on HC emission. If the mixture is too lean

manufacturing, auto-ignition of the fuel does not occur, leading to unburned emissions. If a mixture is too rich, HC is left unburned due to insufficient mixing.

6.9 CARBON MONOXIDE EMISSION

Table 6.10: CO emission

S1	0.007	0.009	0.012	0.015	0.017
S2	0.006	0.008	0.01	0.013	0.015
S3	0.01	0.013	0.015	0.018	0.023
Diesel	0.008	0.013	0.018	0.023	0.029

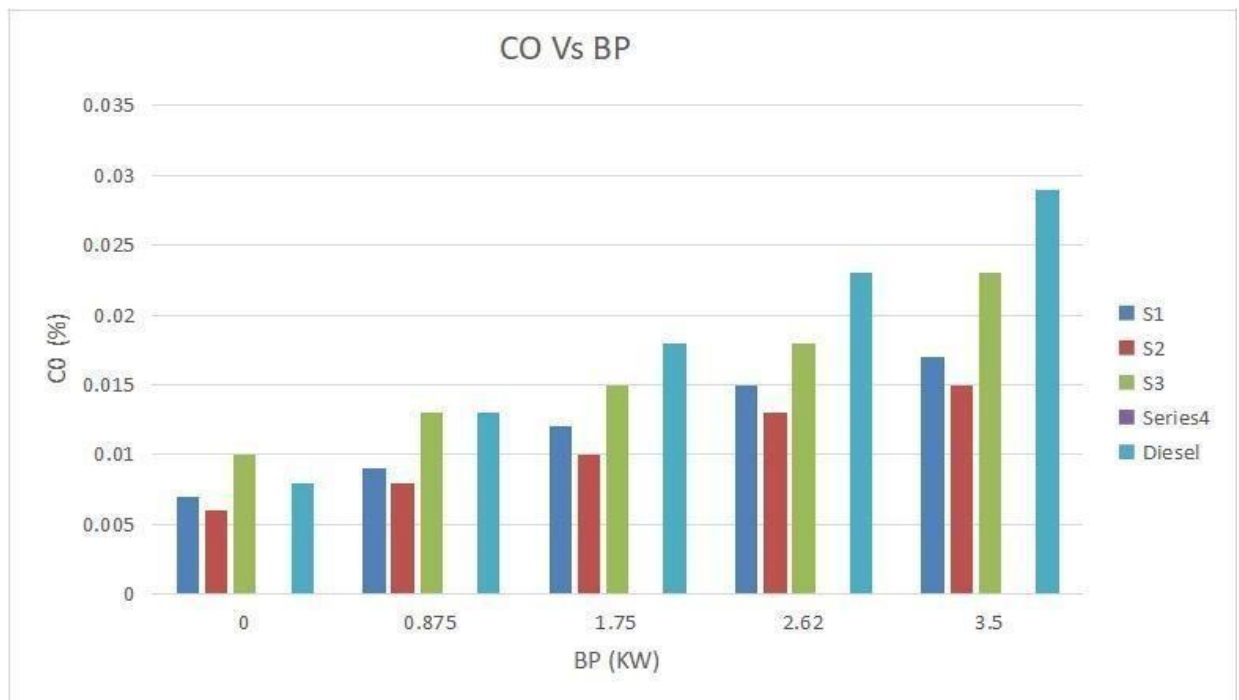


Figure 6.5: CO emission Vs Brake power

This is true because of its low viscosity, which improves spray characteristics and encourages greater air-fuel mixing. As opposed to different blends of biodiesel, 90D10NO50HA has the least carbon dioxide emissions of 0.017% and 70D30NO50HA had the greatest CO emission of 0.029%. This is caused by the

lower viscosity, which encourages better combustion. The 100D, or pure diesel, emits the largest amount of CO₂ 0.029% at 3.5 KW, according to our observations.

6.10 NO_x EMISSION

Table 6.11: NO_x EMISSION

Sample/BP(kw)	0	0.875	1.75	2.62	3.5
S1	37	125	198	287	364
S2	32	98	193	269	341
S3	54	105	204	310	480
Diesel	56	156	289	485	750

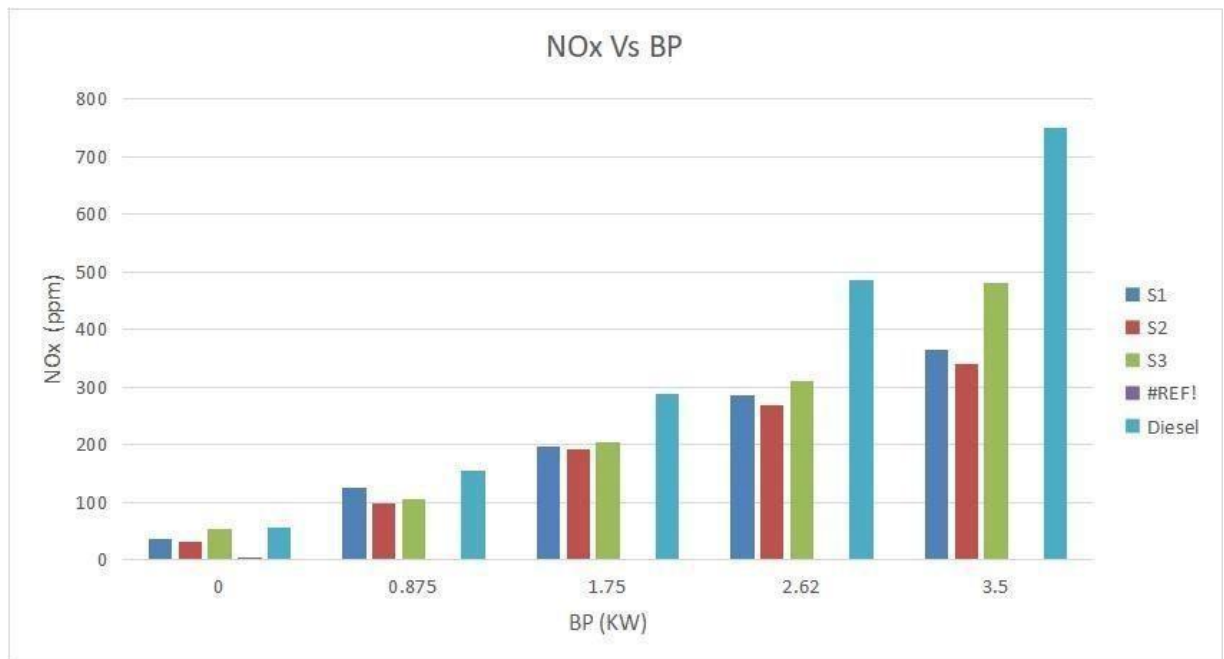


Figure 6.6: NO_x emission Vs Brake power

Figure 4.5 shows that when compared to other blends, 90D10NO50HA has the least NO_x emission at 341 ppm and 70D30NO50HA has the highest at 750 ppm due to the blend's lower viscosity. There are 398 and 381 parts per million in the blends 85D15NO50HA and 75BD25NO50HA, respectively. According to our research, the 100D has the highest Nitrogen output at 750 ppm, with diesel typically containing 500 to 1000 ppm of NO_x.

6.11 CO₂ EMISSION

Table 6.12: CO₂ emission

Sample/BP(kw)	0	0.875	1.75	2.62	3.5
S1	0.25	0.45	0.8	1.05	1.2
S2	0.3	0.7	0.9	1.2	1.3
S3	0.6	0.8	1.2	1.7	2.1
Diesel	1.6	1.96	2.54	2.89	2.98

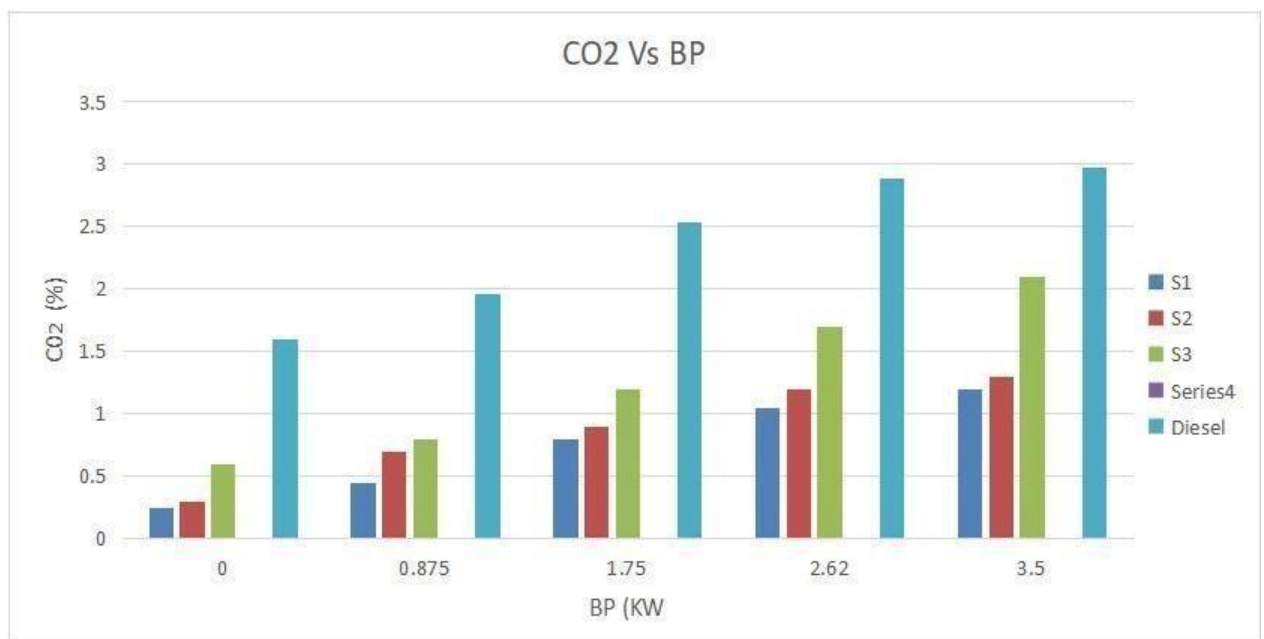


Figure 6.7: CO₂ emission Vs Brake power

According to our observations, the 100D, or pure diesel, releases the most CO₂ at 3.5 KW, or 2%. Lower viscosity and improved combustion result in greater combustion temperatures when compared to the other biodiesel blends. . As was said earlier, biodiesel burns more effectively than diesel because it contains oxygen. 70D30NO50HA emits the greatest CO₂ (2.1%), while 90D10NO50HA produces the least (1.32%).

6.12 O₂ Emission

Table 6.13 :O₂ Emission

Sample/BP(kw)	0	0.875	1.75	2.62	3.5
S1	20.3	19.9	19.7	19.42	19.1
S2	20.1	19.83	20.6	19.9	19.4
S3	20.1	19.92	19.6	19.1	18.67
Diesel	18	19	15	12	11

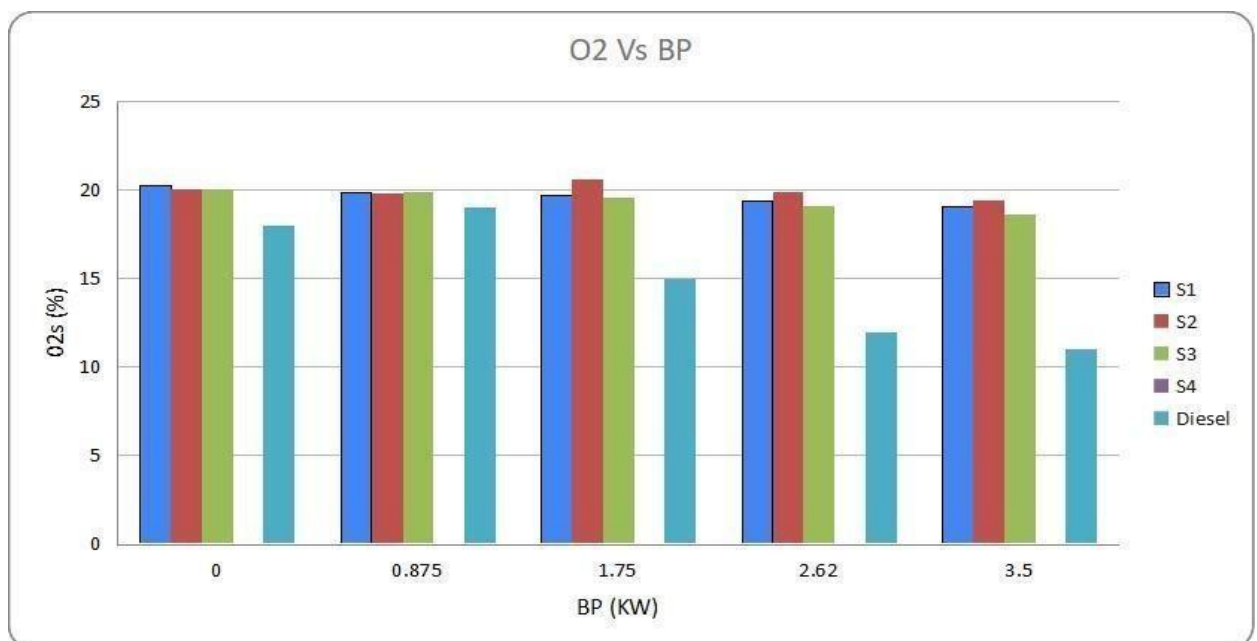


Figure 6.8: O₂ Emission vs Brake power

In this graph the O₂ Emission is higher than the diesel. These are just a few points to consider for your report on oxygen emissions. You may want to research more about the specific factors that affect oxygen concentrations in combustion processes, as well as the potential health and environmental impacts of different levels of oxygen emissions. Research has shown that the use of biodiesel in diesel engines can result in slightly higher oxygen concentrations in the exhaust gases compared to conventional diesel fuel.

CHAPTER 7

CONCLUSION

Biodiesel is an alternative fuel for conventional diesel and can be directly used as fuel in a diesel engine without any modifications to the engine. Transesterification is the most common method for biodiesel production. Waste cooking oil is a cost effective and promising feedstock. WCO with higher FFA content results in a decrease in the overall yield. In this case, esterification is to be done before Transesterification. Homogeneous catalysts like NaOH and KOH are known for having less reaction time and moderate reaction condition. The biodiesel samples were physiochemically characterized. From the results it was clear that the produced biodiesel fuel was within the recommended standards of biodiesel fuel. Important fuel properties of methyl esters of biodiesel produced from waste cooking oil like viscosity, moisture content, density, flash point and fire point, calorific value etc., were found out and compared to the properties of ASTM standard biodiesel. From the engine testing results it was clear that, Efficiency and fuel consumption is good compared to the pure diesel but emission is slightly higher than the pure diesel.

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