

EFFECT OF CORN OIL-BASED BIOFUEL WITH AL₂O₃ NANO-ADDITIVES ON DIESEL ENGINE PERFORMANCE

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering degree 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)

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **SANTHOSH.M (38150708)**, **AMARNATH SURYA.R (38150701)** who carried out the project entitled "**EFFECT OF CORN OIL-BASED BIOFUEL WITH Al_2O_3 NANO-ADDITIVES ON DIESEL ENGINE PERFORMANCE**" under our supervision from December 2021 to March 2022.

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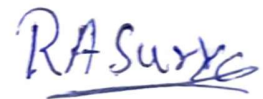
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DECLARATION

We, **SANTHOSH M (38150708)** and **AMARNATH SURYA R (38150701)** hereby declare that the Project Report entitled “**EFFECT OF CORN OIL-BASED BIOFUEL WITH Al_2O_3 NANO-ADDITIVES ON DIESEL ENGINE PERFORMANCE**” done by us under the guidance of **Prof. Dr. S.P. VENKATESAN M.E., Ph.D.** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.



DATE: 10.05.2022

PLACE: CHENNAI

SIGNATURE OF CANDIDATES

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ABSTRACT

Due to the increasing depletion of petroleum reserves, biodiesel is one of the most potential alternative sources of energy fuel in the transportation industry because of the rising demand for energy as well as environmental pollution threats. There are several edible and non-edible vegetable feed stocks for biodiesel production, metal-based additives, as well as differences in physio-chemical characteristics, and their impact on performance and emission aspects of biodiesel production discussed in this article. The effects of nano-metallic additions like Al_2O_3 on characteristics, performance, and emission were thoroughly examined. This evaluation is limited to papers that have been critically analysed and preserved. Non-edible oil-based biodiesel is one of the finest sources of energy, according to this assessment. For improved biodiesel characteristics and lower emissions, several kinds of nano-metallic additive may be used. Because of their comparable qualities, biodiesel made from maize oil holds potential as a replacement for regular diesel fuel. Al_2O_3 nanoparticles are employed as an addition to a corn oil methyl ester (COME) emulsion in the current study. Nanoparticles of Al_2O_3 are disseminated in the emulsions at 50, 75, and 100 ppm. In order to investigate the impact of metal oxide nanoparticles on the fuel's emission characteristics, a single cylinder, four-stroke, direct injection CI engine is being used with B20 and B20 doped with Al_2O_3 nanoparticles at various concentrations. An oxidation catalyst, nanoparticles have a favourable impact on emission characteristics, according to experimental data.

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CHAPTER 1

INTRODUCTION

It is clear that climate change is affecting a wide range of Earth ecosystems, such as forests, marine environments, and more, and the primary cause of this change is global warming. The Earth's atmosphere has warmed dramatically in the last century, compared to earlier centuries. Increase in automotive usage and emissions, as well as fossil fuel use in thermal power plants to generate electricity for both personal and commercial customers are key factors in these developments. As a nonrenewable resource, petroleum's fuel supply is rapidly depleting as demand for electricity production and transportation rises.

There are several applications where compression ignition engines are employed as a power source because to their high mechanical and thermal efficiency, low fuel consumption, and high resilience. Nearly 68% of the country's gasoline and oil needs are met by imports from other nations, resulting in significant outflows of local currency.

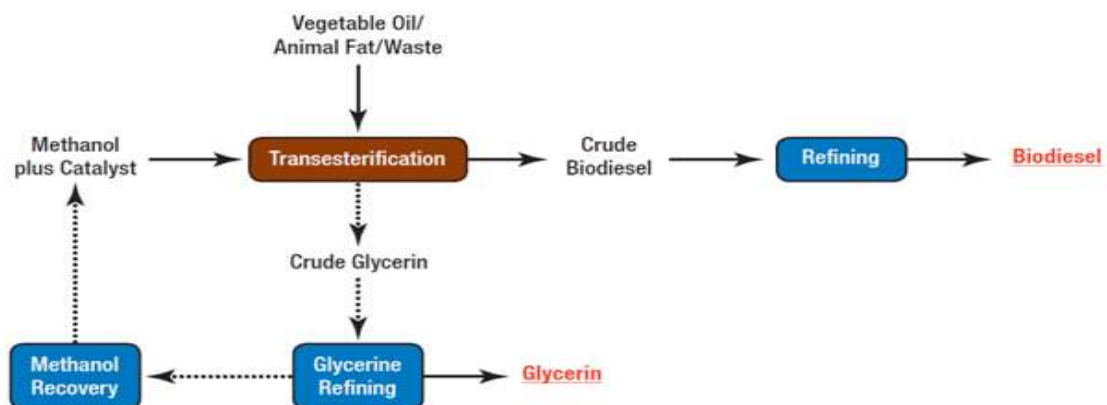


Fig.1.1 Schematic of Biodiesel Production Path

Petroleum diesel is the primary source of energy for industrial, agricultural, and transportation sectors, but demand is growing rapidly and depletion is also

increasing. Unburned hydrocarbon (UBHC), CO, and NO_x are released into the atmosphere at dangerous levels as a result of the use of this product, which is required by law. Besides causing pollution, exhaust emissions also contribute significantly to global warming. Engine modification, fuel modification, and exhaust gas retreatment are some of the most frequent ways used to improve the performance of diesel engines. A diesel engine's performance may be increased to some degree by adjusting the injection time, the valve timing, the compression ratio, and the inner-part anti-wear coatings or linings. Engine changes, on the other hand, are not always the cheapest or most convenient alternative. Physio-chemical qualities may be improved by adding catalysts or other additions to the basic fuel. Both performance and emissions may be improved by mixing in the additives properly. The performance of a diesel engine may be greatly boosted by employing a turbocharger or supercharger, which does not need extra power supply.

In order to manage and treat the hazardous exhaust gas emissions from a diesel engine using techniques such as exhaust gas recirculation, catalytic converters, and particle filters, among others

1.1 BIODIESEL AND IMPORTANCE OF ADDITIVES

One of the finest alternatives to petroleum diesel fuel is biofuel. Toxic-free, non-explosive, less flammable, and most importantly biodegradable, mono-alkyl esters of long-chain fatty acids (biodiesel). Palm, Jatropha, Pangamic, Grape seed Mahua Castor Cotton seed Tobacco seed Rubber seed Rice bran Neem Coconut Sunflower oil etc. are some of the natural sources of biodiesel. "Transesterification" is the chemical process by which the alcohol is added to the crude oil under moderate conditions in the presence of a base catalyst, making the crude oil more stable. The oil's triglycerides are converted to alkyl esters and glycerol during the esterification process. Methanol or ethanol is used in the transesterification process, which takes place at temperatures ranging from 50°C to 80°C. sodium hydroxide (NaOH) and potassium hydroxide (KOH) are often employed as base catalysts (KOH). A variety of techniques are used to make biodiesel, including the ultrasonic reactor process, the supercritical process,

lipase-catalyzed approach, and the batch reactor process. Generally, biodiesel feedstock is divided into edible and non-edible forms of vegetable oil. We'll go through some of India's most popular edible and non-edible feedstocks right now.

1.2 EDIBLE FEED STOCKS

Zea mays, the scientific name for corn, is a member of the Poaceae family. The germinated maize is used to produce corn oil. It grows slowly and slowly up to a height of 6 metres in tropical regions. To extract 85 percent of maize germ oil from its kernels, a solvent extraction technique employing nhexane or 2-methyl pentane is used. Soybean is an annual plant of the Fabaceae family. Food and oil industries use soybeans as a source of protein. It contains 18% to 20% fat and oil, 40% protein, and small amounts of cellulose, glucose, ash, and fibre. It also contains cellulose, glucose, ash, and fibre. Soybean oil is extracted using the percolation extraction method in the presence of n-hexane. Approximately 75 to 240 litres of oil may be extracted from each hectare in the production of Brassica napus (Canola). In oil with a concentration of 35% to 42%, solvent extraction is often used to extract the oil. Tropical and subtropical climates often cultivate Arachishypogaea (Peanut, also known as groundnut or goober), which yields best on light, sandy soils with pH values ranging from 5 to 7 and soil temperatures ranging from 0°C to 35°C It is believed that between 45% and 52% of the oil is removed by prepressing, with the remainder extracted using the solvent extraction process. The mesocarp of Chamaeropshumilis (Palm) is used as a feedstock for the extraction of edible oil. It is most often found in warm and tropical locations across the world. Beta-carotene levels are high and the oil content is predicted to be between 48 and 52 percent. Screw pressing is used to extract the oil. As a member of the Arecaceae family, Cocosnucifera (Coconut) is often cultivated in coastal places with hot and humid climates. Using the dried kernel (copra) of the coconut, one may extract the oil. Rotating chucks and oil expellers are used to extract the oil, which has a concentration of 65-72 percent. An extract from Vitis vinifera (grape seed) called proanthoctandins is high in poly unsaturated fat, with a polyunsaturated fat content of 69.6 percent. A variety of Asian rice known as Oryza sativa, which is popular in Asian nations like India, is high in carbs. It is referred to as rice bran oil because it is made from the oil that is taken from the rice husk's hard outer covering. Oleic acid predominates, making it suitable for

human consumption. Rice bran oil is extracted using a solvent extraction process. An Asteraceae species native to North America, *Helianthus annuus* (Sunflower) has been extensively grown as a decorative plant and a food crop. 44 to 50 percent of the oil in sunflower kernels is oleic acid-rich. Sunflower seeds are compressed to obtain their oil.



Fig.1.2 Edible Feed Stocks

1.3 NON-EDIBLE FEED STOCKS

Sapotaceae is the family of *Madhuca indica* (Mahua), which hails from central and northern India. A major producer of oleaginous seeds in Central India, this tree is one among the region's most significant. The seed's oil content ranges from 33% to 43%, depending on who you ask. A non-edible, high oil-yielding Euphorbiaceae crop, *Ricinus communis* (Castor) is found in tropical locations. High-pressure continuous screw press extraction using n-heptane as solvent is

used to extract 40 to 50 percent of the castor bean's oil. One of the most common species of Fabaceae (Pongami) found in the tropical and subtropical regions of Asia is *Millettia pinnata* (*Pongamia*). It may thrive in a broad variety of soils and climates. Expeller and cold pressing and solvent extraction methods remove 30-40% of the oil in this mixture. Tropical and drought-resistant, *Jatropha curcas* (*Jatropha*) belongs to the Euphorbiaceae family and produces oil-rich seeds with a content of 37% to 40%. *Jatropha curcas* strains with 75 percent oleic acid have recently been created by Temasek life science lab and JOilPte limited in Singapore for use as biofuels. Mechanical press expellers are used to remove the oil from the oil sands.

Meliaceae family *Azadirachta indica* (Neem) from India is present in all agro-climatic zones with soil pH values of 10 except in cold areas. Thirty to fifty percent of the oil in neem seeds is extracted using mechanical pressing, steam pressing, and solvent extraction. There are a few plants that can thrive in the driest of circumstances, but not in soil that is prone to floods and significant waterlogging. *Simmondsia chinensis* (Jojoba), which is from the family Simmondsiaceae, is one of them. Mechanical pressing, leaching, and solvent extraction are used to extract the seed's oil, which makes up approximately half of the oil produced from the seed. In warm areas, *Nicotiana glauca* (Tobacco) of the Solanaceae family is a non-edible, green leafy plant with oil content ranging from 17% to 26%. Tobacco seed oil is extracted using an Indian-origin solvent in all save the coldest agroclimatic zones with soil pH values of 10. Thirty to fifty percent of the oil in neem seeds is extracted using mechanical pressing, steam pressing, and solvent extraction. There are a few plants that can thrive in the driest of circumstances, but not in soil that is prone to floods and significant waterlogging. *Simmondsia chinensis* (Jojoba), which is from the family Simmondsiaceae, is one of them. Mechanical pressing, leaching, and solvent extraction are used to extract the seed's oil, which makes up approximately half of the oil produced from the seed. A non-edible, green leafy plant from the Solanaceae family, *Nicotiana glauca* (Tobacco) is cultivated in warm areas and has a seed oil content of between 17% and 26%. Oil from the tobacco seed is recovered by solvent extraction and steam distillation processes. In the Euphorbiaceae and Crotonoideae families, *Hevea brasiliensis* (Rubber tree) is

native to African and Brazilian nations. Presently it is abundantly grown in Southern Peninsular India. Soxhlation and mechanical expeller extraction are used to remove the linoleic and oleic acids from the rubber seed oil.

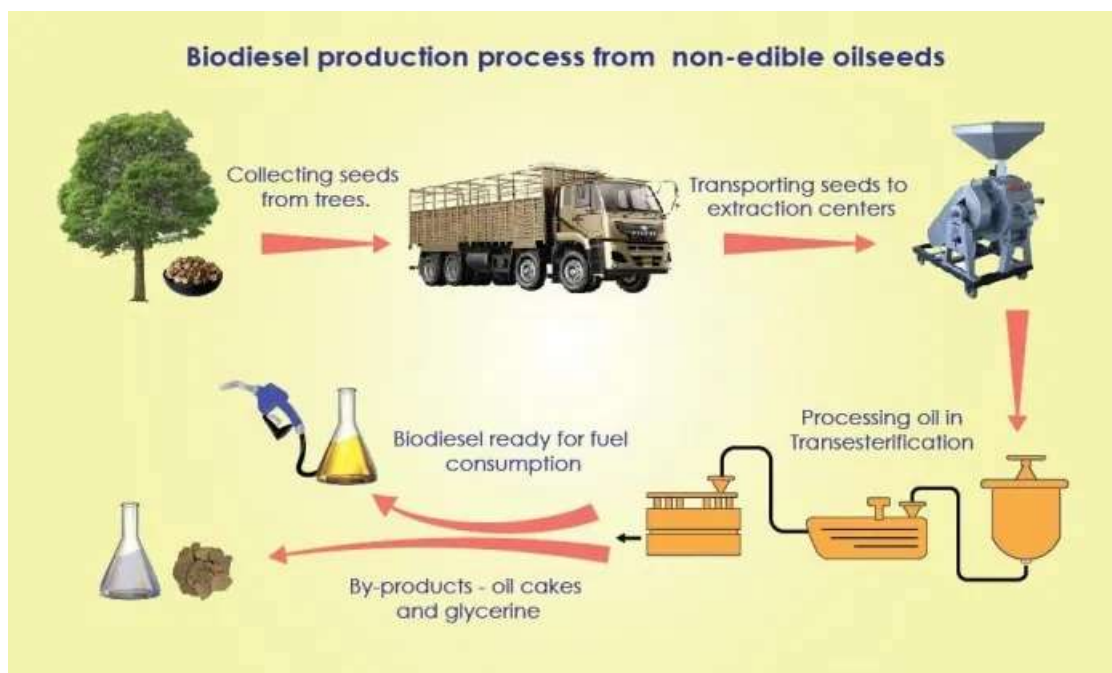


Fig.1.3 NON-Edible Feed Stocks

1.4 FUEL ADDITIVES AND ITS IMPORTANCE

There are a variety of additives that may be used to enhance the performance of a fuel without changing its combustion properties. These include organic or metal-based compounds that can be readily dissolved in fuel. Smaller amounts of fuel additives (100 ppm to several thousand ppm) are used. Product categories include refinery, distribution, and automobile performance enhancers for gasoline additives. Subcategories include antioxidants, cetane enhancers, anti-knock, antifreezing agents, stability enhancers, additives to prevent corrosion, cold flow enhancers, fuel carried catalysts, anti-wear agents and more.

Antioxidants Because of the transesterification method used to make biodiesels, they are ready to react with oxygen when exposed. In order to prevent the biodiesel in the diesel blend from oxidising, chemicals such as BHT, TBHQ (Tert-butyl hydroquinone), BHA (Butylatedhydroxyanisole), PG (Propyl gallate),

and PA (Pyrogallol) are combined with it.

Chemical compounds with a higher oxygen content are added to the fuel in a small amount to enhance the fuel's burning properties. It is common practise to utilise oxygenated components like biodiesel and ethanol as an addition since they are easy to mix and blend with diesel and can be stored for long periods of time.

Improve the cold flow behaviour using these additives. Wax in biodiesel starts to crystallise when the temperature drops below freezing, which influences the cold filter plug point (CFPP). Using additives such as ethylene vinyl acetate copolymer, glycerol ketals, glycerol acetates, phthalimide and succinimide copolymers, which increase the cloud point property of the fuel, may help prevent this problem.

Enhancements to increase Cetane count

The cetane number is one of the most important elements in determining the quality of the gasoline since it represents the fuel's capacity to ignite. Compression ignition engines benefit from higher Cetane-number fuels because they burn cleaner. Adding nitro compounds, such as nitro carbonates, nitro alkanes, and peroxides, to the gasoline raises its cetane number.

Additives based on metals This may be done by adding metal and metallic oxides of micro or nano sizes in ppm or percentage by weight ratios to the fuel in order to enhance its burning properties. To enhance the fuel physio-chemical qualities, metals including iron, aluminium, manganese, silver, gold, copper, boron and silica are utilised as additions. Metal oxides like aluminium oxide (Al_2O_3), cerium oxide (CeO_2), titanium oxide (TiO_2), and zinc oxide (ZnO) are also used as additives. Magnalium (Mg-Al) and carbon nanotubes (CNT) are also employed as metal-based additives that increase the performance of fuels by modifying their physiochemical characteristics. Metallic and metallic oxide nano additions are shown in Figure 2 as performance enhancers. Many studies have shown that altering fuel's physio-chemical qualities, rather than altering the engine itself, gives greater outcomes in terms of improving engine performance and reducing exhaust pollution levels. The use of biodiesel as a fuel has been proven to be advantageous due to the lower levels of exhaust emissions, ignition delay, cold flow characteristics, and other performance features.

Applying biodiesel as a fuel may shorten a person's lifespan, according to some studies, however this can be remedied by using fuel additives. Fuel

modification by adding metal and metal oxide nano-additives to diesel engines is the primary subject of this review study. Various types of biodiesel and biodiesel with nanometal-based additives, as well as their impact on engine performance and pollution control, have been thoroughly reviewed by the authors. Nano-fuel additives have been studied by a number of researchers, and their effects on performance and exhaust emissions under various operating circumstances are also reported in this work. Students, researchers, engineers, and anyone who deal with IC engines would benefit from this review study on nano-fuel additives for CI engines.

1.5 EFFECT OF NANO METALLIC ADDITIVE ON FUEL'S PHYSIOCHEMICAL PROPERTIES

Researchers from Attia et al. studied the impact of B20-Jojoba methyl ester with the addition of aluminium oxide nano particle on the properties of fuel and performance and emission characteristics of the diesel engine. The results indicated that the fuel characteristics had significantly changed. The addition of Al_2O_3 also led to a decrease in the fuel's kinematic viscosity and an increase in density and cetane number. JBD30A mix was found to have a 4.25 Cst, 875 kg/m³ and 38.9 MJ/kg calorific value with the addition of 30 ppm Al_2O_3 and CeO_2 to Jatropha methyl ester, as reported by Prabhu Arockiasamy et al. The fuel properties of the JBD30C mix were determined to be 4.30 Cst, 876 kg/m³ and 38.7 MJ/kg. The fuel's characteristics were enhanced by mixing alumina with Jatropha biodiesel. Aluminum nanoparticles increased the fuel characteristics of B20Mahua biodiesel produced by Syed Aslam and Saravanan.

CHAPTER-2

LITERATURE REVIEW

Syed Aslam et al. clearly shown that the inclusion of alumina nanoparticles improved the ZJME25 fuel characteristics. When used in conjunction with ZJME25, AONP50 produced better outcomes than AONP25 when it had a higher flash point and Cetane number. B20-Soybean biodiesel additives utilised by Shaadi and Velraj include alumina, ethanol, and isopropyl alcohol. Scientists tested a D80SBD15E4S1 blend that included 100 mg/l of AONP and found that both viscosity and calorific value plummeted, but the Cetane number shot up.

This combination of AONP with Canola Methyl Ester Emulsion and Straight Diesel led to an increase in flash point, density, and viscosity when compared to straight diesel alone. With and without AONP and CNT, SadhikBasha and Anand examined JME's fuel characteristics. For increased fuel characteristics, the findings suggested that the combination of CNT with JBD was more effective. When compared to pure Jatropha biodiesel and AONP blended Jatropha biodiesel, the flash point of the CNT mixed version was the lowest. When biodiesel was mixed with CNTs, the flash point, viscosity, calorific value, and cetane number were all raised as a consequence. The results showed that as the concentration of CNTs increased, so did the values. The inclusion of CNT alters the characteristics of HOME, as mentioned by Prajwal Tewari and colleagues. Conclusion: HOME+50 ppm CNT outperformed HOME+25 ppm CNT, according to the author.

When SadhikBasha and Anand tested the CNT-blended JME water emulsion, they discovered its flash point was 1220C, the lowest of the blends. The viscosity, density, calorific value, and cetane number all rose in tandem with the rise in CNT concentration. An rise in flash point, fire point, density and viscosity was seen by Karthikeyan et al. when ZnO was added to B20-Grape seed oil. Increased calorific value was achieved by incorporating ZnO and CeO₂ nanoparticles into straight diesel and biodiesel including B20-Pomoline stearin wax, according to Rao & Srinivas Rao and Karthikeyan et al.

An investigation on the burning properties of different nanoparticles was conducted by YananGan and colleagues. A thin coating of carbon between 2 and 6 nanometers thick covered iron nanoparticles ranging in size from 15 to 80 nanometers, and a non-spherical boron nanoparticle ranging in size from 80 nm to 80 nm were investigated.

Biodiesel made from waste frying palm oil was studied by Kannan et al. and shown to have a higher calorific value, higher kinematic viscosity, and a higher FBC (FeCl₃) content when compared to a control batch.

The addition of AgNP with HOME reduced the flash point value, while increasing the viscosity, density, and calorific values, according to NagarajBanapurmath et al. HOME+50 ppm of Ag had better effects than HOME alone.

graphene NPs increased the characteristics of Home, according to Bhagwat et al. When compared to the other mixes, HOME+50 ppm graphene has the most improved properties.

The newest developments in nano fluids, their production, and their applications were discussed by Mohd. Suhail Ansari et al. One-step and two-step nanofluid synthesis were categorised into two categories.

Fueled by nanoceria-added biodiesel derived from waste frying oil, Abbas AlliTaghipoorBafghi et al. investigated the performance and emissions of an air-cooled single cylinder four stroke diesel engine. Diesel-biodiesel blends containing 5 to 25 ppm of CeO₂ with a particle size ranging from 10 to 30 nm were tested.

Adding CeO₂ to a JME+TPO mix lowered the viscosity and density, while CNT added the same, but the viscosity and density were raised by the addition of CNT.

Viscosity decreased by up to 20.37 percent and flash point by up to 7 percent when Mn (12 mol/L) was added to B25 of pomace oil, SinemCaynak discovered. The pouring temperature was lowered from 00C to -150C as a result. Physiochemical characteristics of diesel, biodiesel and fuel combined with nano metallic additions are shown in Table 1.

A number of studies have shown the relevance of adding nano metals to biodiesel, and the influence they have on enhancing the biodiesel's physio-chemical qualities.

CHAPTER-3

AIM AND SCOPE OF THE PROJECT INVESTIGATION

With this research, we want to investigate the emissions and performance of a C3, C4, and Biodiesel direct-injection Diesel engine (sesame and palm oil). In addition to BTHE and SFC, the effectiveness of the brakes is examined.

Engine performance at various rated powers was examined in terms of SFC, Brake Thermal Efficiency (BTHE), and emissions parameters such as HC, CO, CO₂, and NO_x. The transesterification technique is used to make biodiesel from sesame oil and palm oil. An engine with a DI Diesel engine is used to test the biofuel. Prior to adding any of the test mixes, the engine was allowed to run at idle for a period of time to establish baseline data on emissions and performance.

3.1 CORN OIL

Extracting the oil from the germ of corn is the process of making corn oil (maize oil) (maize). Refined maize oil has a high smoke point, making it an excellent frying oil. Some margarines also use it as a main component. Corn oil is less costly than the majority of the other vegetable oils available on the market.

Biodiesel may be made from a variety of oils, including corn oil. Soap, salve, paint, erasers, rustproofing metal surfaces, ink and textiles, nitroglycerin and pesticides are just a few of the other industrial applications for maize oil. Pharmaceutical formulations employ it as a vehicle for medication compounds.

Hexane or 2-methylpentane are the solvents of choice for most maize oil extraction (is hexane). The solvent is collected and re-used once it has been evaporated from the maize oil. Degumming and/or alkali treatment, both of which remove phosphatides, are used to refine maize oil after extraction. As well as eliminating colour, alkali treatment neutralises free fatty acids (bleaching). Winterization (the removal of waxes) and deodorization of the oil by steam distillation at 232–260 °C (450–500 °F) under high vacuum are the last processes in refinement.

Unrefined, 100%-expeller-pressed maize oil is produced by a few specialised oil makers. Due to its lower yield and lesser market share, this is a more costly product than one made using a combination of the expeller and the solvent method.

Fig.3.1 Corn Oil



Biodiesel is a kind of diesel fuel made from long-chain fatty acid esters obtained from plants or animals. A methyl, ethyl, or propyl ester is often produced by chemically interacting lipids like animal fat (tallow), soybean oil, or any other vegetable oil with an alcohol.

Biodiesel, on the other hand, is a drop-in biofuel, which means that it can be utilised in existing diesel engines and distribution systems. However, since most engines cannot operate on pure Biodiesel without modification, it is commonly mixed with Petro Diesel (normally at a concentration of less than 10%). Oil may be made from biodiesel mixtures.

Mono-alkyl biodiesel is defined by the National Biodiesel Board of the United States of America as biodiesel.

3.2 TESTING METHOD

3.2.1 FLASH POINT

A volatile material's flash point is the lowest temperature at which its vapours will ignite in the presence of an ignition source in chemistry. The autoignition temperature, the temperature at which spontaneous ignition occurs, is sometimes mistaken with the flash point. Once the ignition source is withdrawn, the vapours will continue to burn at the lowest possible temperature. There may not be enough vapour to support combustion above the flash point, which is why it is higher than the flash point. Indirectly, neither the flash point nor the fire point are influenced by the temperature of the ignition source, although both are much greater.

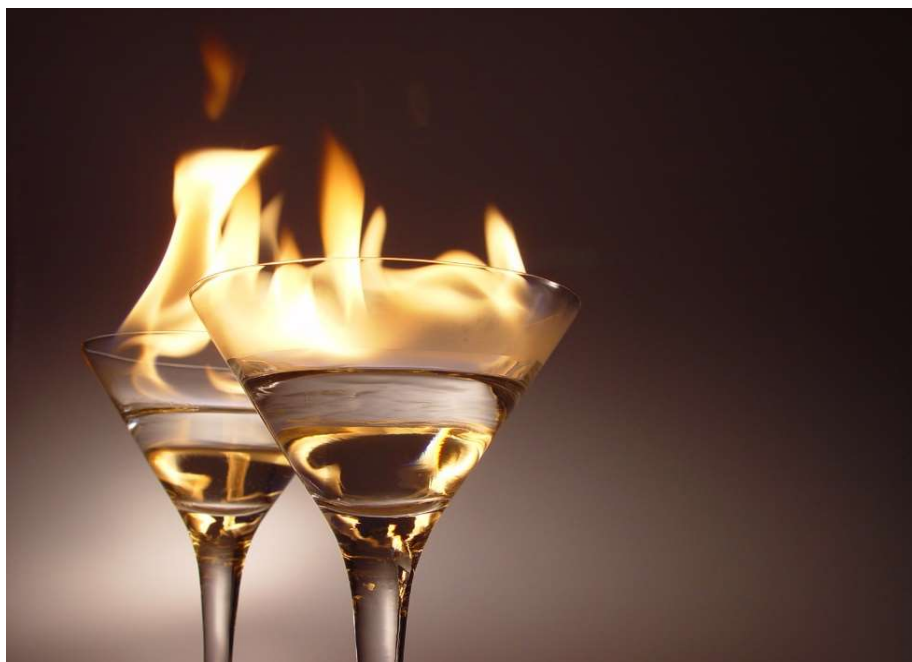


Fig.3.2 Flash Point

3.2.2 MEASUREMENT

The open cup and closed cup methods of measuring the flash point are the most common. Open cup devices use a heated open cup with a flame passed over the surface to heat the sample. At a certain height, the recorded flash point temperature will be exactly the same as the real fire point, which is why it is so important to measure the flash point accurately. The Cleveland open cup is the most well-known example of this (COC).

Non-equilibria, like Pensky-Martens, where the vapours above the liquid are

not in temperature equilibrium with the liquid, and equilibria, like Small Scale (commonly known as Seta flash), where the vapours are deemed to be in temperature equilibrium with the liquid, are the two types of closed cup testers. Both of these kinds of cups include a cover that allows the ignition source to be inserted into the cup. A closer approximation to the temperature at which the vapour pressure approaches the lower flammable limit is provided by closed cup testers rather than open cup testers (usually 5–10°C or 9–18°F lower). Non-equilibria testers TAG and Abel, both of which may chill the sample below ambient for low flash point materials, are alternatives to Pensky-flash Marten's point testers.

3.2.3 FIRE POINT

This kind of internal combustion engine, known as an ICE or an IC engine, uses a combustion chamber as an integrated element of the working fluid flow circuit for the burning of a fuel (typically air). The expansion of the high-temperature and high-pressure gases generated by combustion in an internal combustion engine provides direct force to an engine component. A rotor, piston, turbine blade, or nozzle is normally where the force is applied. As a result of this force moving the component, chemical energy is transformed into useable kinetic energy, which is utilised to push or power the engine. Replacement for external combustion engines in settings where weight or size are a factor



Fig.3.3Fire Point

CHAPTER-4

EXPERIMENTAL METHOD

4.1 WORKING AND CONSTRUCTION

This kind of internal combustion engine, known as an ICE or an IC engine, uses a combustion chamber as an integrated element of the working fluid flow circuit for the burning of a fuel (typically air). The expansion of the high-temperature and high-pressure gases generated by combustion in an internal combustion engine provides direct force to an engine component. A rotor, piston, turbine blade, or nozzle is normally where the force is applied. As a result of this force moving the component, chemical energy is transformed into useable kinetic energy, which is utilised to push or power the engine. Replacement for external combustion engines in settings where weight or size are a factor



Fig 4.1 Experimental Setup

4.1.1 REACTIONS

Biodiesel and its impure coproduct, glycerol, are produced via base-catalyzed transesterification, which combines lipids (fats and oils) with alcohol (usually methanol or ethanol). Biodiesel may be made by reacting fatty acids with alcohol using an acid-catalyzed esterification process if the feedstock oil is acidic. A chemical reaction that decreases the quality of a material may be avoided or

minimised using other technologies such as fixed-bed reactors,[3] supercritical reactors, and ultrasonic reactors.



Fig 4.2 Engine Testing Lab

4.1.2PRODUCT PURIFICATION

Biodiesel, soap, glycerol, excess alcohol, and trace quantities of water are all byproducts of the process. To fulfil the requirements, all of these byproducts must be eliminated, although the sequence in which they are removed depends on the method.

This characteristic difference is used to separate the majority of the glycerol coproduct from the biodiesel product. Distillation is the most common method for reusing methanol that is left over after a process. Removing soaps or turning them into acids is an option. The gasoline is carefully cleaned to eliminate any remaining water.



Fig.4.3 Purification

4.1.3TRANSESTERIFICATION

In the case of animal or plant fats, triglycerides, which are esters generated by the reactions of glycerol with three fatty acids, are the building blocks. The additional alcohol (often methanol or ethanol) is deprotonated using a base to increase its nucleophilicity during the transesterification process. The triglyceride and alcohol are the only sources of energy for this process, as seen in the figure. Heat and catalysts (acid and/or base) are utilised to speed up the reaction since it would otherwise happen very slowly or not at all. Acid and base are catalysts, not reactants, in the transesterification process, which is crucial to remember. Sodium hydroxide, potassium hydroxide, and methoxide are all common catalysts for transesterification. With a base-catalyzed technology that requires modest temperatures and pressures and produces over 98 percent conversion yield from virgin vegetable oils, almost all biodiesel is made from virgin oils (provided the starting oil is low in moisture and free fatty acids). However, acid catalysis may be required for biodiesel generated from other sources or by other processes. Commercial-scale transesterification will be discussed using the base-catalyzed transesterification process.



Fig.4.4Transesterification

4.2 PREPARATION PROCEDURE

The first thing we do is to measure the pure corn oil. According to the recipe that we use now, measure of 100ml. After measuring 100ml of the pure corn oil, the next thing to do is measure the potassium hydroxide. Again, measuring 100ml of the pure corn oil, the next thing to do is to measure the potassium hydroxide, according to our recipe 0.9 grams (Solid particles) of potassium hydroxide is to be measured in next process. Using the cylinder, Measure the 26ml Methanol required use the funnel to avoid pulling it. In the process, Potassium Hydroxide is used catalyst and isn't consumed up after the reaction is complete, Sodium Hydroxide can also be use as catalyst. Now, add the Methanol and to the flask. Continue to shake the flask until the Potassium Hydroxide is completely dissolved. Good quality Biodiesel can be obtained by checking the properties of oil. When the potassium hydroxide is completely is completely dissolved, we proceed to the Transesterification process. Prepare the setup the reactor, Inside the reactor there is a stirrer to continuously stir, we have claps to hold the setup from collapsing and there is a motor which rotates the stirrer. Set the desired temperature at 65

degrees Celsius is required for water bath, Put the oil in the reactor and wait until it reaches 65 degrees Celsius. Wait couple minutes so that the oil temperature reaches the set temperature and now add potassium hydroxide and methanol mixture in the reactor. The reaction takes place in the reactor is called as Transesterification. The reaction results are two products are Biodiesel and glycerol or glycerin which is well known in its application in the cosmetics. We have the condenser and it is used to condensate the methanol back to the reactor. Claps are used to avoid the condenser from shaking while the motor starts to move the stirrer. After Measuring 100ml of the pure corn oil, the next thing to do is measure the potassium hydroxide. Again, measuring 100ml of the pure corn oil, the next thing to do is to measure the potassium hydroxide, according to our recipe 0.9 grams (Solid particles) of potassium hydroxide is to be measured in next process. But avoid tightening the claps, otherwise the condenser may crack. Now open the water which circulates through the condenser, the water will make methanol condense. Switch on the motor and we make the reaction to continue for 1 hour continuously. This is done to achieve complete transesterification reaction. The product from the reaction is going to be put into the settler, inside the settler two layers will be formed. We'll let the reaction run for an hour now, and you'll see two layers. Glycerin is the substance at the bottom, while Biodiesel is the substance on top. But this Biodiesel is not yet ready to use, it contains impurities are needs to be purified. Water washing or distillation may be used to purify it. Initially, supply the engine with electrical power to ensure that it is operating at a steady speed. The engine should be run for 15 minutes to stabilise. Open the burette valve after closing the diesel supply valve. Once you've done that, turn on the burette's diesel supply valve to replenish it. Keep the diesel flowing by closing the burette valve. To figure out how much air the engine is taking in, record the measurement on the manometer. Take note of the temperature of the engine jacket entrance and exit using a thermometer. With the use of a water metre and a stopwatch, determine the water flow rate. Use a 100 percent tachometer to record the spring balance and engine rpm. Repeat the experiment with a different amount of electricity. Reducing the strain on the engine and pressing the liver supplied on the right-hand side of the engine will bring the engine to a stop. Then shut off the engine's gasoline and water lines.

4.2.1 COB 10

Properties of Diesel 65% + Corn Oil 10%.

SL.NO	TEST PARAMETERS	TEST METHODS	RESULTS
1	Kinematic Viscosity @27°C (brook field –DVE-60 rpm, so1)	ASTM D 445	128 CP
2	FLASH LIGHT (OPEN CUP)	ASTM D 92	226°C
3	FIRE point (OPEN CUP)	ASTM D 92	275°C
4	POUR POINT	ASTM D 97	-35°C

4.2.2 COB 20

Properties of Diesel 75% + Corn Oil 20%.

SL.NO	TEST PARAMETERS	TEST METHODS	RESULTS
1	Kinematic Viscosity @27°C (brook field –DVE-60 rpm, so1)	ASTM D 445	129 CP
2	FLASH LIGHT (OPEN CUP)	ASTM D 92	228°C
3	FIRE point (OPEN CUP)	ASTM D 92	272°C
4	POUR POINT	ASTM D 97	-38°C

4.2.3 COB 30

Properties of Diesel 85% + Corn Oil 30%.

SL.NO	TEST PARAMETERS	TEST METHODS	RESULTS
1	Kinematic Viscosity @27°C (brook field –DVE-60 rpm, so1)	ASTM D 445	131 CP
2	FLASH LIGHT (OPEN CUP)	ASTM D 92	229°C
3	FIRE point (OPEN CUP)	ASTM D 92	271°C
4	POUR POINT	ASTM D 97	-37°C

4.3 Engine Specification

Electric start Diesel engine with VCR (Variable Compression Ratio) is coupled to an eddy current type dynamometer for loading in this experiment. A tilting cylinder block layout allows the compression ratio to be altered without halting the engine or changing the combustion chamber geometry. Instruments for measuring combustion pressure and crankshaft angle are included in the setup. Engine indicators for PPV diagrams connect these indications to the computer. In addition, airflow, fuel flow, temperature, and load monitoring may all be connected. In addition to the stand-alone airbox and two fuel tanks, the panel box also includes a manometer, a fuel measuring device, transmitters for air and fuel flow measurements, and an engine indicator. Rotameters are used to monitor the flow of cooling water and the water used in the calorimeter. The setup allows for the study of VCR engine performance with EGR for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/Fratio, and heat balance, among other metrics. Engine Soft, a LabVIEW-based Engine Performance Analysis software suite, is available for on-the-fly performance assessment. Optionally available is a computerised diesel injection pressure measuring system.

4.3.1 TEST PROCEDURE

All tests were done under consistent state conditions with no changes to the test motor. The temperature of the greasing up oil was kept up with between 85 -C and 90 -C. Tests were conveyed out at steady surrounding temperature to work on the unwavering quality of the accounts. The motor was permitted to run for 10 min for adjustment previously the readings were recorded. For the whole load range, motor testing were conducted at a constant speed of 1500 r/min. The infusion pressure is kept steady (21MPa) in this review. The motor was first run at its standard infusion timing with diesel fuel which structures the reference fuel for this review. The pattern information was recorded. Then the motor was powered with the mixes COB10, COB20, and COB30 at its standard injection timing. The EGR rates were continuously expanded close by utilizing the EGR control valve. Afterward, the infusion timing was impeded by 2- CA BTDC and again the test fuel

ISB30 was run. Every single test was rehashed multiple times to guarantee repeatability. In order to use the petrol that had remained in the fuel tank from the previous preliminary, the engine was often allowed to run for quite some time before being refuelled.

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Comp.)
Product code	234
Engine	Make Kirloskar, Type 1 cyl., 4 stroke Diesel, water cooled, power 3.5kW at 1500rpm, stroke 110mm, bore 87.5mm. 661cc, CR17.5, Modified to VCR engine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250ks/s.
Piezo powering unit	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100°C, 3 Nos; Thermocouple, Range 0-1200 °C, 2 Nos
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	"EngineSoft" Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump	Type Monoblock
Overall dimensions	W 2000 x D 2500 x H 1500 mm
Optional	Computerized Diesel injection pressure measurement with injection variation 0-25 deg BTDC

Table4.1 Specification of the Test Engine

4.3.2 ENGINE TESTING SOFTWARE

Apex Innovations Pvt. Ltd. created EngineSoft, a Labview-based software suite, for use in engine performance monitoring systems. Monitoring, reporting, dataentry, and data logging are only some of the functions provided by EngineSoft. Fuel use and heat output are evaluated by the programme. It may be adapted to the engine's specifications. At various operating conditions, different graphs are generated. In RUN mode, the engine's essential signals are read,

recorded, and shown in graph form while it is being tested on-line. To see data in graphical and tabular representations, the user opens a stored data file. Graphs and results may be saved and printed. Having the data in an Excel spreadsheet allows for additional investigation.

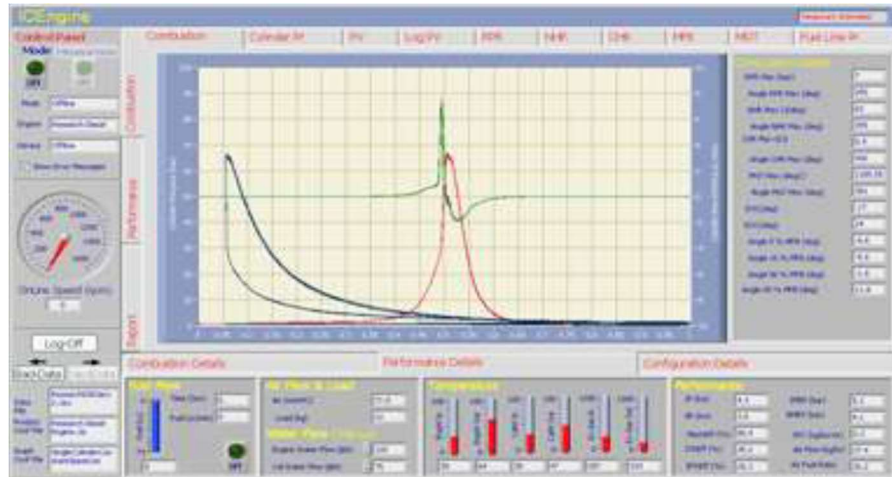


Figure 4.5: EngineSoft

4.3.3 Gas Analysis

The five-gas analyzer detects the concentration of exhaust byproducts such as Carbon Monoxide (CO), Carbon Dioxide (CO₂), Hydro Carbons (HC), Oxygen (O₂), and Nitric Oxide (NO_x). This is accomplished by inserting a probe, also known as a detector, into the tailpipe. Connect the 5-gas analyzer to the computer, turn on the gas analyzer, push the zero button after connecting the hose and probe. The analyzer is ready to sample exhaust emissions gas after the zero is complete. The emission readings are displayed in the analyzer and are noted.

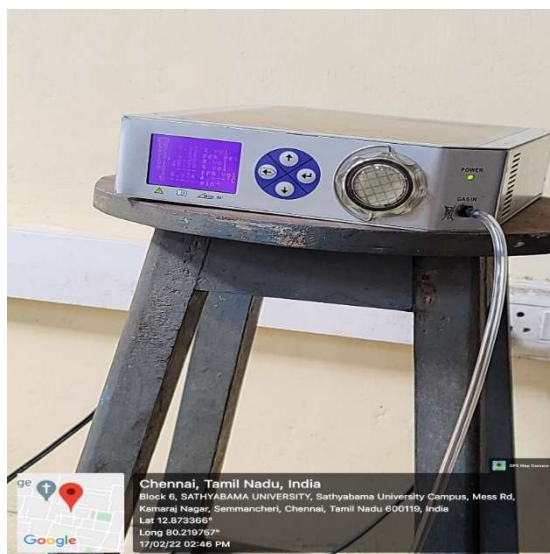


Figure 4.6: Gas Analysis

CHAPTER 5

RESULT AND ANALYSIS

5.1 RESULT

Three samples S1, S2, and S3 of petroleum diesel blended with 10%, 20%, and 30% of the trans-esterified biodiesel are produced. There are totals of 300ml in each sample. Fueled with Corn oil biodiesel, the engine's performance and emissions were compared to diesel operation at three different volumetric fuel mixes with petroleum diesel at varied loads.

BLEND	HC	CO	CO ₂	O ₂	NO _x
S1	3	0.017	0.7	19.97	105
	5	0.023	1.1	19.17	197
	7	0.034	1.4	18.79	227
	9	0.047	1.9	18.27	315
	14	0.056	2.4	17.56	423
S2	3	0.02	0.8	19.78	121
	4	0.027	1.1	19.64	187
	8	0.031	1.4	19.01	219
	11	0.043	1.7	18.68	347
	13	0.052	2.1	18.31	413
S3	4	0.02	1	19.62	115
	7	0.031	1.6	18.83	207
	11	0.047	1.8	18.17	315
	13	0.054	2.1	17.18	420
	17	0.068	2.5	17.09	523

Table5.1: Emission values from experiment

ICEngineSoft Test Report

Report Date : Mon, Feb 21, 2022 , Time : 12:03:55 PM
Organization : ENGINE TESTING CENTRE, Operator : Operator
Data File : S1.xlsx, Last Modified Date: Thu, Feb 17, 2022,
Config. File : Research Diesel Engine.xls

Engine Details :

ICEngine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 17.50, Swept volume 661.45 (cc)

Combustion Parameters :

Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m³) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.39, Number Of Cycles : 10, Cylinder Pressure Reference : 7, Smoothing 2, TDC Reference :-11

Performance Parameters :

Orifice Diameter (mm) : 20.00, Orifice Coeff. Of Discharge : 0.60, Dynamometer Arm Length (mm) : 185, Fuel Pipe dia (mm) : 12.40, Ambient Temp. (Deg C) : 27, Pulses Per revolution : 360, Fuel Type : Diesel, Fuel Density (Kg/m³) : 830, Calorific Value Of Fuel (kJ/kg) : 42000

Fig 5.1 IC Engine Test Report

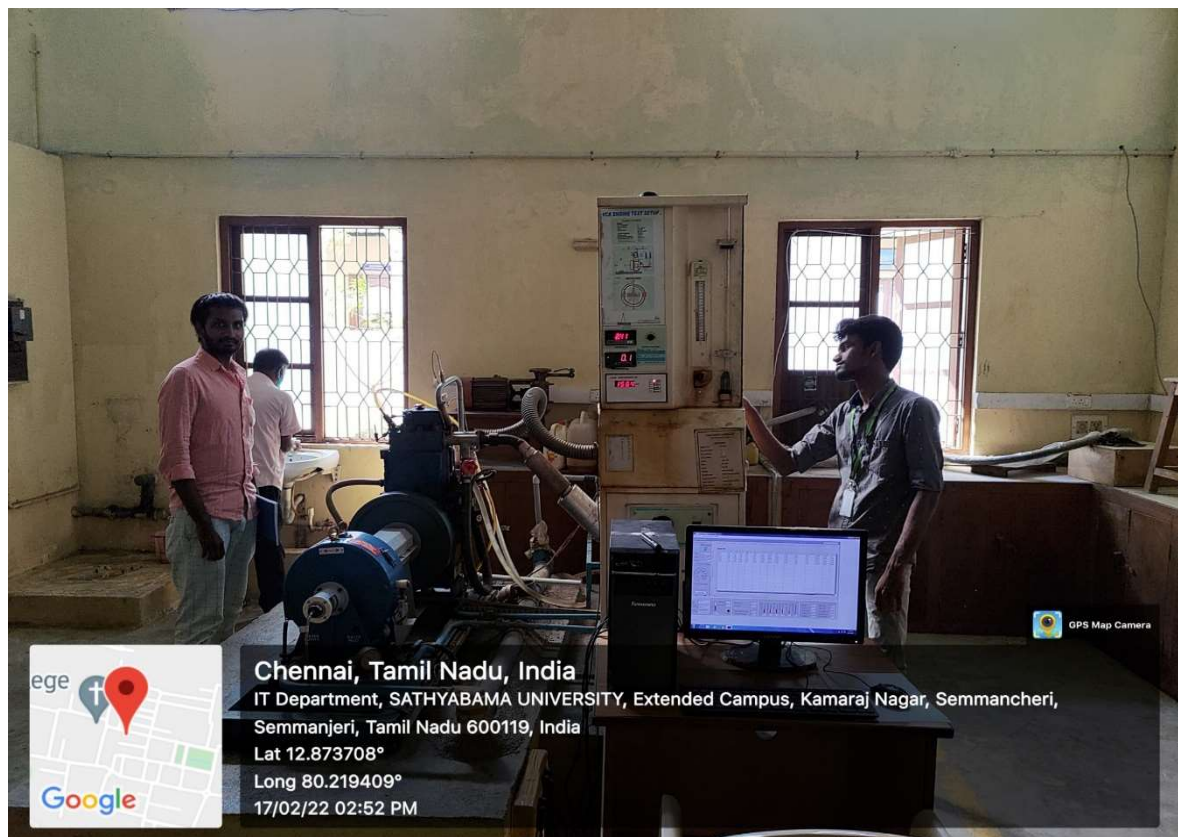


Fig 5.2 IC Engine

5.2 EMISSION ANALYSIS

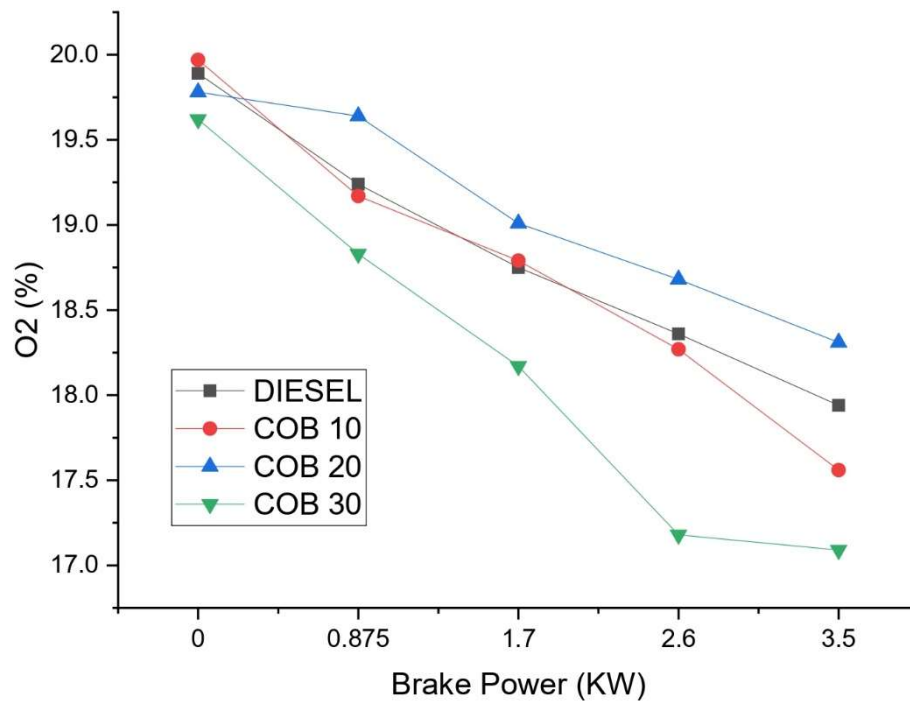
5.2.1 O₂ Emission

This graph represents the emission of oxygen gas during the combustion of sample fuel and neat diesel. COB 10 emits more oxygen for the first three power inputs. The COB 20 also emits a similar level of oxygen content. The oxygen emission from the diesel decreases as the power increases. The reason that the oxygen content should be is, If the engine does not receive enough oxygen during the combustion process, complete conversion of carbon and hydrogen is impossible, resulting in particulates and carbon monoxide, which leads to increased exhaust emissions. The highest oxygen emission is noted as 19.97% (COB 10) at no load condition and the least as 17.09% (COB 30) at load condition 3.5KW

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	19.97	19.17	18.79	18.27	17.56
COB 20	19.78	19.64	19.01	18.68	18.31
COB 30	19.62	18.83	18.17	17.18	17.09
Diesel	18	19	15	12	11

Table 5.2: O₂ vs BP

Graph representing O₂ Emission



Graph 5.1: O₂ vs BP

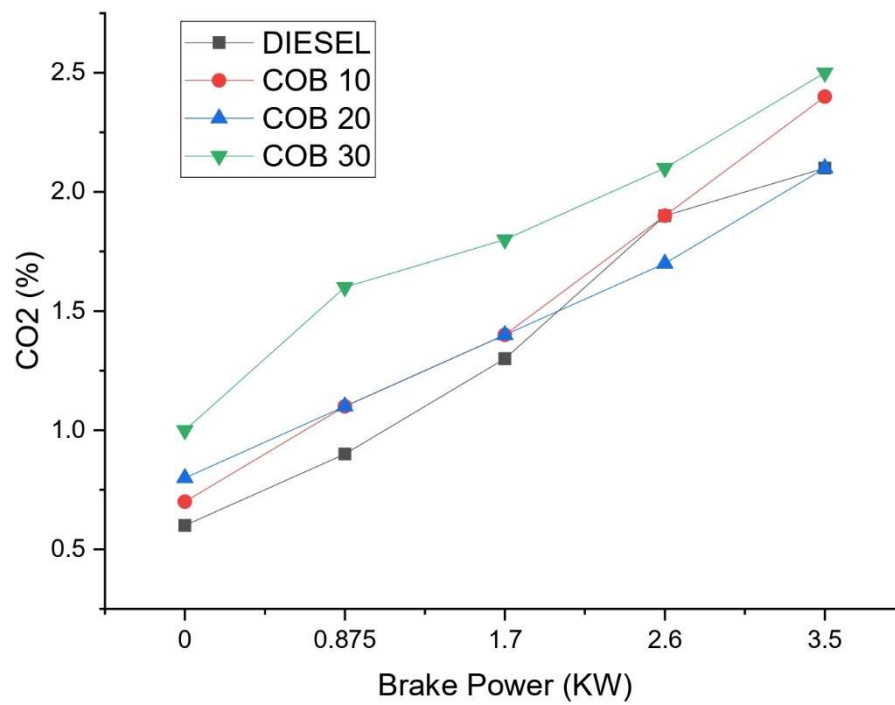
5.2.2 CO₂ Emission

This indicates the emission of carbon di oxide gas during the combustion of samples and neat diesel. Reducing the carbon emissions is one of the main goals to achieve on a global level to reduce the impact of greenhouse effect and problems arising from it. The carbon emissions cannot be reduced all of a sudden but steps taken towards its reduction may help future breakthroughs. The high CO₂ emission from neat diesel is obviously clear, whereas its biodiesel mixed counterparts are emitting less CO₂. COB10 has the least CO₂ emission of 0.7% at no load condition. COB 30 has the highest emission of 2.5% at the load condition of 3.5KW.

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	0.7	1.1	1.4	1.9	2.4
COB 20	0.8	1.1	1.4	1.7	2.1
COB 30	1	1.6	1.8	2.1	2.5
Diesel	1.6	1.96	2.54	2.89	2.98

Table 5.3: CO₂ vs BP

Graph representing CO₂ Emission



Graph 5.2: CO₂vs BP

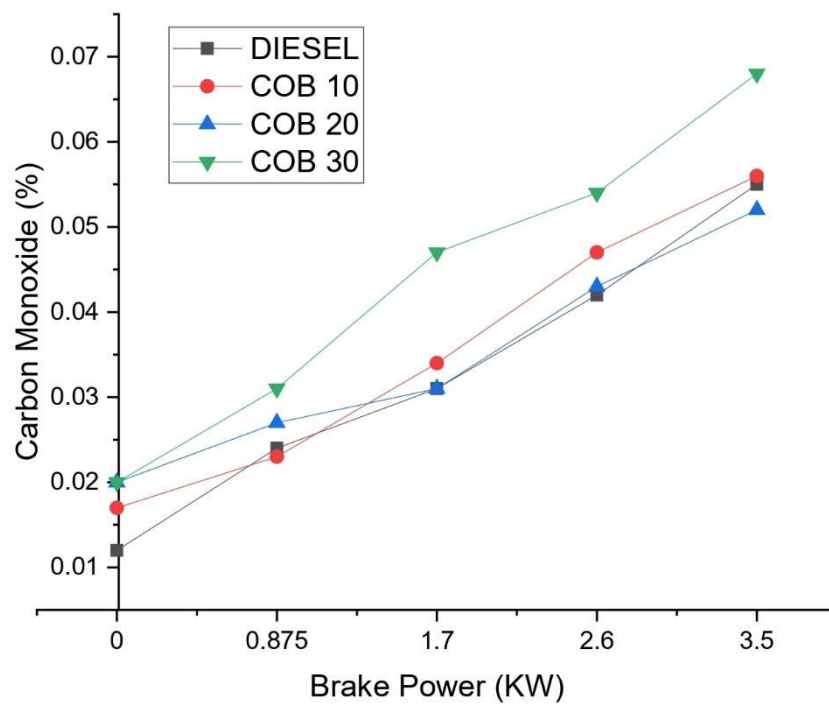
5.2.3 CO Emission

The incomplete combustion process in an engine results in the release of carbon monoxide (CO) as a waste product from the vehicle's exhaust system. Carbon monoxide (CO) is produced when combustion processes are not completed due to an oxygen deficit or insufficient mixing. Carbon monoxide is a colourless and odourless gas that may be found in almost any environment. However, carbon monoxide has a short-term impact on the respiratory system and is not dangerous. Red blood cells are unable to absorb oxygen because carbon monoxide attaches to them. The neat diesel emits less CO than the other samples.

BP(KW)	0	0.88	1.75	2.62	3.5
COB 10	0.017	0.023	0.034	0.047	0.056
COB 20	0.02	0.027	0.031	0.043	0.052
COB 30	0.02	0.031	0.047	0.054	0.068
Diesel	0.01	0.01	0.02	0.02	0.03

Table 5.4: CO vs BP

Graph representing CO Emission



Graph 5.3: CO vs BP

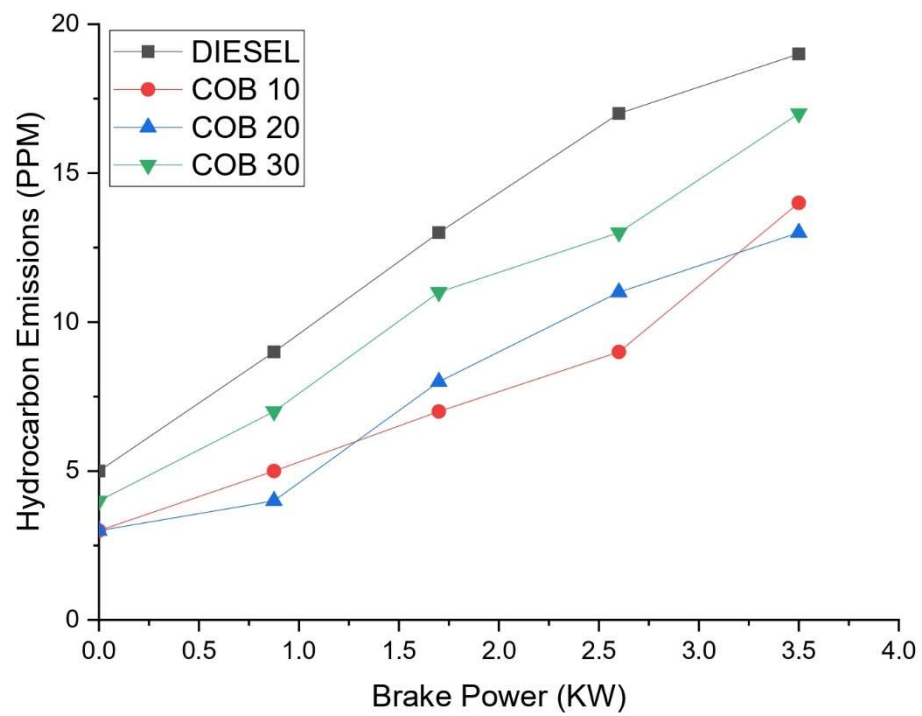
5.2.4 HC Emission

Dirty or leaky spark plugs, open-circuiting or faulty wires, or damaged ignition coils may all lead to a lack of spark energy in a car. A shortage of spark energy might cause high HC emissions. If the spark happens at the incorrect moment, it might result in incomplete combustion and excessive hydrocarbon levels. The COB 10 emits less HC among all. HC emission from every bio-diesel blend were less compared to plain diesel. COB 10 emitted the less HC (1%) in relative to the other samples.

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	3	5	7	9	14
COB 20	3	4	8	11	13
COB 30	4	7	11	13	17
Diesel	2	6	10	15	19

Table 5.5: HC vs BP

Graph representing HC Emission



Graph 5.4: HC vs BP

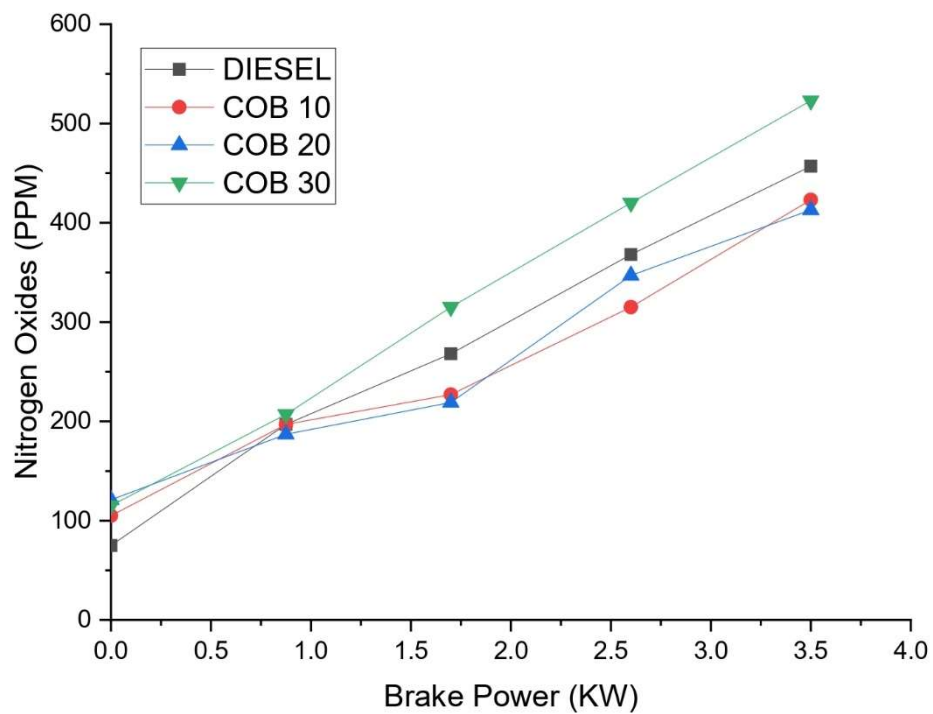
5.2.5 NOx Emission

When nitrogen and oxygen combine in the air, especially at high temperatures, NO_x is generated during combustion. In areas where there is a lot of traffic, such as large cities, the quantity of nitrogen oxides released into the atmosphere may be tremendous. The graph represents the emission of NO_x gas produced during emission. The reason why NO_x emission is bad for environment is that, Humans can suffer serious health consequences from NO_x, including respiratory diseases. Acid rain and ground-level ozone generation are caused by NO_x emissions, which can impact ecosystems, animals, and plants. When NO_x combines with ammonium (NH₄⁺), water vapor, and other substances, it produces nitric acid (HNO₃) and tiny particles. The COB30 by a big difference reduces the emission of NO_x and is least among the other. COB10 has similar has similar emission results with slight increment of NO_x level.

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	105	197	227	315	423
COB 20	121	187	219	347	413
COB 30	115	207	315	420	523
Diesel	56	156	289	485	750

Table 5.6: NO_x vs BP

Graph representing NO_x Emission



Graph 5.5: NO_x vs BP

5.3 EMISSION ANALYSIS

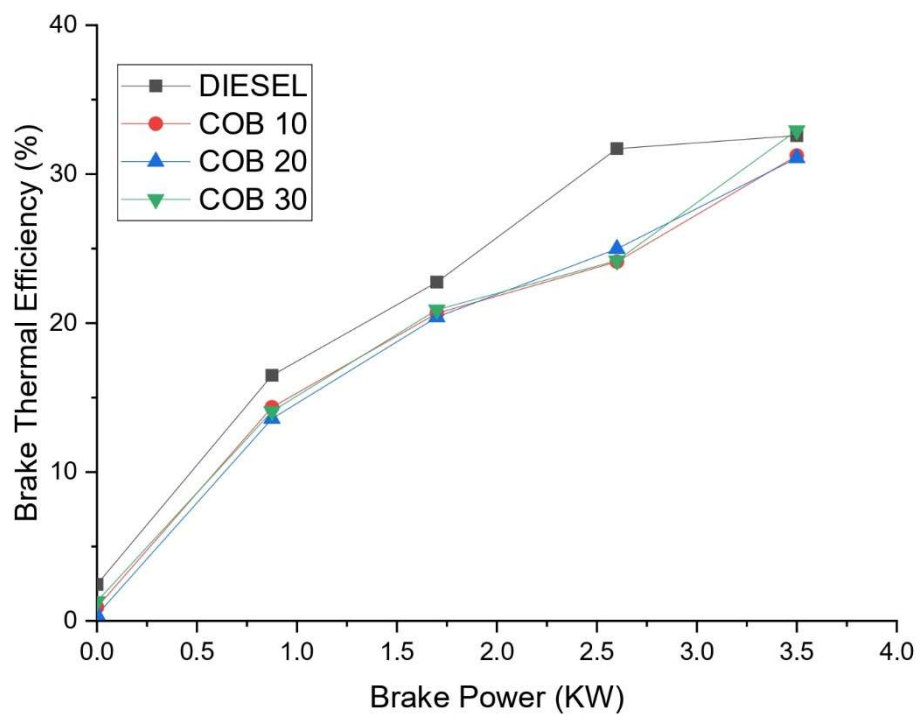
5.3.1 Brake Thermal Efficiency

The ratio of braking power at the engine crankshaft to the power produced by fuel combustion is known as the brake thermal efficiency. The brake thermal efficiency shows how much of the overall power generated by burning the gasoline is absorbed by the engine crankshaft. The graph shows the break thermal efficiency of a diesel engine using sample bio-diesel and neat diesel. The performance of each COB is comparable to that of plain diesel. Overheating, brake fade, and brake pad deterioration are few issues that might occur. Significant braking inefficiency is caused by vapor lock and a mushy pedal sensation. Brake Thermal Efficiency (BTE) for COB 30 is 32.34 percent, which is lower than the baseline diesel's BTE of 32.59 percent when the vehicle is fully loaded.

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	0	14.34	20.66	24.12	31.24
COB 20	0	13.58	20.4	24.98	31.08
COB 30	0	14.08	20.89	24.2	32.34
Diesel	0	16.49	22.75	29.47	32.59

Table 5.7: BTE vs BP

Graph Representing Brake Thermal Efficiency Analysis



Graph 5.6: BTHE vs BP

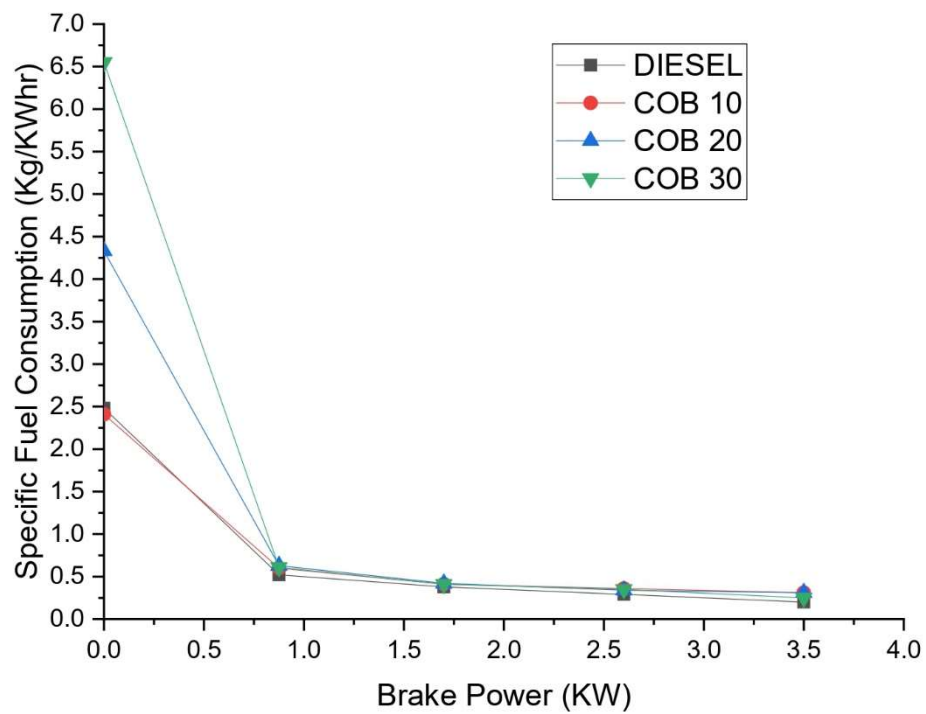
5.3.2 Specific Fuel Efficiency

The term "specific fuel consumption" refers to the quantity of fuel used per unit time in order to produce a certain engine power (SFC). The SFC measures the efficiency with which an engine converts fuel into kinetic energy. Brake-specific fuel consumption is used to assess the fuel efficiency of any prime mover that consumes fuel and generates rotational or shaft power. To compare the efficiency of IC engines with their shaft output, it is most usually utilised. The rate of fuel consumption is divided by the quantity of energy created to arrive at this number. The SFC of COB 20 was the least (0.29%) compared to other COB and plain diesel which shows COB 20 consumed the less fuel compared to the rest.

BP(KW)	0	0.875	1.75	2.62	3.5
COB 10	2.41	0.6	0.41	0.36	0.31
COB 20	4.33	0.63	0.42	0.34	0.29
COB 30	6.55	0.61	0.41	0.35	0.25
Diesel	2.45	16.49	22.75	29.47	32.59

Table 5.8: SFC vs BP

Graph representing Specific Fuel Efficiency



Graph 5.7: SFC vs BP

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

A single-cylinder, constant-speed, direct-injection engine was used to test the performance and emissions of biodiesel and a mix of the fuel. In this experiment, the emission patterns demonstrated a difference between different diesel and biodiesel blends. Different fuels produced different amounts of usable heat, which might be a sign of the energy content of the fuels being different.

6.2 CONCLUSION

- O₂ emissions of all samples were higher than diesel in all load conditions. Sample 3 emits more oxygen for the first three power inputs. The highest oxygen emission is noted as 19.97% (COB 10) at no load condition and the least as 17.09% (COB 30) at load condition 3.5KW
- The high CO₂ emission from neat diesel is obviously clear, whereas its biodiesel mixed counterparts are emitting less CO₂. COB10 has the least CO₂ emission of 0.7% at no load condition. COB 30 has the highest emission of 2.5% at the load condition of 3.5KW.
- At all load levels, the CO emission of each sample was somewhat higher than that of ordinary diesel. The least emission is noted in sample 1 (0.01%) at no load condition which is same as diesel and the highest is observed as 0.05% at full load condition.
- HC emission from every bio-diesel blend were less compared to plain diesel. COB 10 emitted the less HC (1%) in relative to the other samples.
 - NOx emission of all samples were relatives less compared to plain diesel except no-load condition. COB10 had the least emission of 105 ppm at no load condition and COB20 had the highest emission of 121 ppm in full load condition.
 - Brake Thermal Efficiency is 32.34 percent at full load for COB 30 compared to 32.59 percent for baseline diesel at full load.

- The SFC of COB 20 was the least (0.29%) compared to other COB and plain diesel which shows COB 20 consumed the less fuel compared to the rest.
 - Understanding the process of producing biodiesel is a difficult endeavor. The presence of water or fatty acids, as well as operational circumstances such as catalyst concentration, temperature, reaction duration, and alcohol concentration, are only a few of the many variables to consider while analysing a chemical reaction. Increasing catalyst volume, temperature, reaction duration, and alcohol volume all have the potential to boost yields.
 - As a result, the yield tends to stabilise or even decline when the variables have reached an optimum. Extreme circumstances promote side reactions such as saponification, hydrolysis of esters, and difficulty separating when extra alcohol is present. These side reactions may be explained by the promotion of alkalinity (the quantity of catalyst) and reaction temperature during the process.
 - Many of these components interact in an erratic fashion that makes it difficult to discern which influence is more important in any given scenario. As a result, no two experiments are the same, making extrapolation difficult.
 - Instead than describing in detail how to maximise biodiesel production yields, this study's major contribution is to propose methods for finding the optimal balance between various factors. Best benefit-cost ratios use enough excess alcohol to provide a good yield without overspending; avoid catalyst waste because increasing the amount of catalyst has no significant effect on yield; and further reduce expenses with energy and operating time because long reactions aren't required for a good outcome. Due to these operational concerns, a minor percentage increase in yield that would be irrelevant in reality due to other expenditures is compensated for by a technological enhancement.

- This paper also demonstrates that biodiesel manufacturing involves more than engineering. An crucial part of a country's social and economic development. It has a direct influence on the energy industry, which is strongly linked to a country's resources and productive structure. The modern world's progress depends on abundant access to reliable sources of energy.

7. REFERENCES

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