

**EXPERIMENTAL ANALYSIS ON EMISSION
CHARACTERISTICS OF ENGINE POWERED BY
SAFFLOWER OIL AND KARANJA OIL ADDED WITH
ALUMINIUM OXIDE NANOPARTICLES**

Submitted in partial fulfilment 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

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MAY 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of Edwin Kishore J(Reg.No.39150040) and S.Vishal (Reg.No.39150134) who carried out the project entitled "**EXPERIMENTAL ANALYSIS ON EMISSION CHARACTERISTICS OF ENGINE POWERED BY SAFFLOWER OIL AND KARANJA OIL ADDED WITH ALUMINIUM OXIDE NANOPARTICLES**" under our supervision from June 22 to May 2023.

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ABSTRACT

The number of cars, companies, and power plants is growing which results in greater CO, HC, and NO_x emissions from these sources. Because of this, people throughout the world are looking for alternative fuels that are harmful to the environment. In this study, the performance, combustion, and emission characteristics of a single-cylinder direct injection diesel engine operating at a constant speed under various operating conditions are examined with the addition of aluminum oxide nanoparticles to safflower and Karanja biodiesel blends. The test fuels have the designations B25 (75 % diesel and 25 % blend), B25A50 (75 % diesel and 25 % mix and 50 ppm aluminum oxide nanoparticles), and B25A100 (75 % diesel and 25 % blend and 100 ppm aluminum oxide nanoparticles), respectively. The best engine performance and lowest harmful engine emissions are achieved when aluminum oxide nanoparticles are added to biodiesel mixes.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF BIO DIESEL:

Biodiesel is an alternative fuel that can replace diesel, and it can be made from various oils, fats, and greases. Farmers can benefit from biodiesel because it creates a new market for vegetable oils and animal fats, allowing them to grow the fuel and use it in their farm machinery. Additionally, using biodiesel can decrease a country's dependency on foreign fuel sources. Biodiesel is a renewable energy source that can reduce NO_x emissions and lower the carbon content in the atmosphere. It contributes less to global warming because the carbon used in the fuel was extracted from the air by the plant feedstock. Compared to diesel made from fossil fuels, biodiesel produces less air pollution, including NO_x, carbon monoxide, and carbon dioxide. According to a 1998 study by the USDA and US DOE, using pure biodiesel in urban buses can reduce life cycle emissions of total particulate matter by around 32%, carbon monoxide by around 35%, and sulphur oxides by around 8% compared to petroleum diesel's life cycle. These benefits were highlighted by Zahira Yaakob, Masita Mohammad, Mohammad Alherbawi, Zahangir Alam, and Kamaruzaman Sopian, as well as Amin Talebian-Kiakalaieh, Nor Aishah Saidina Amin, and Hossein Mazaheri.

1.2 GENERATION OF DIESEL:

Subhash Lahane, K.A. Subramanian survey stated that when this biodiesel came into light many started producing it from food crops. Due to which there was instability in food supply and sudden hike in cost of food crops. So with this the generations of biodiesel have started.

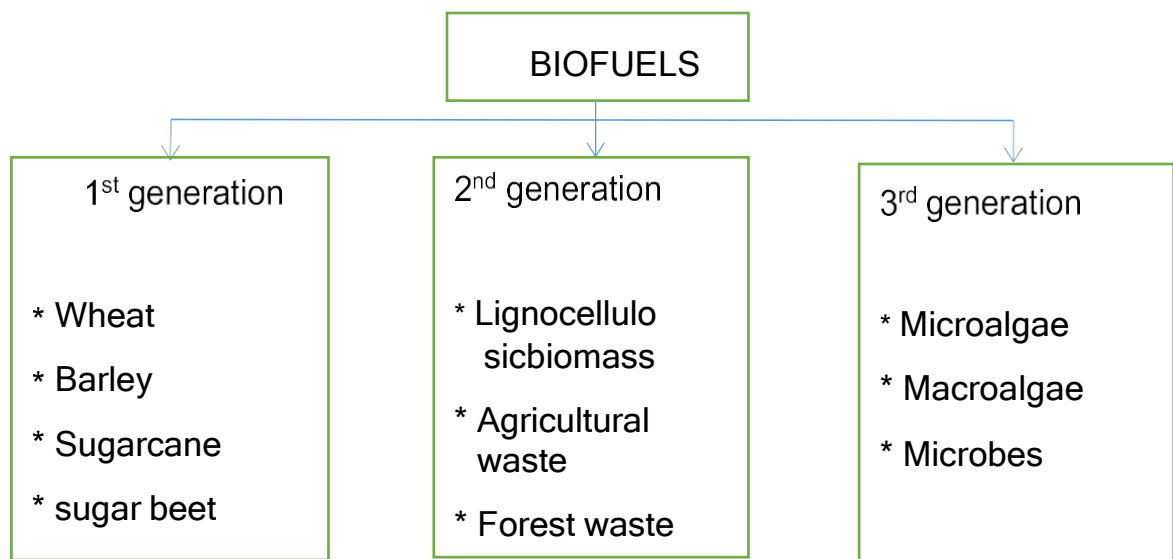


Fig 1.1: Generations of Biodiesel

1.2.2 The First Generation of Biofuels:

According to Mohammad Rasul and Nur Md Sayeed Hassan, the initial type of biofuels are derived from agricultural crops that are essential sources of food for humans. In this generation the biodiesel is made from corn starch, sugar from potatoes and vegetable oil obtained from the crops which humans consume on a daily basis. Scientist feared that it may cause an instability in the environment because of the growing demand for the oils. This would also create competition among the farmers. Thus leading to usage of excess fertilizers and pesticides to increase crop yield. This would change the chemical properties of biodiesel to a certain extent. So this type of production of biodiesel was not entertained.

1.2.3 The Second generation of Biofuels:

Rahman, Md M., and Mohammad Rasul investigations showed that the second generation has come into existence because of the fear of the scientists that the first generation may cause imbalance and shortage of food supply. This led to change of feed stock to non-edible sources such as harvest wastes, municipal solid waste, foods that already fulfilled their purpose (Used cooking oil). These second-generation biofuels are made from cellulosic biomass or waste plant

materials. This helps to decrease the burden on the use of consumable oils in the production of biodiesel. So here no arable land is used solely for production of biodiesel, The manufacturing of biodiesel from leftover animal fat, and the enhancement of its properties through the creation of synthesized nickel and magnesium additives. Energy Convers Management 2009; 50(3).its waste product is used for production of biodiesel. Non-edible foodsecond generation feedstock include used cooking oil, jatropha oil, grasses and other seed oils. To convert cellulose biomass to biodiesel a series of pre-treatment is required.

1.2.3 The Third Generation of Biofuels:

M.Mofijur, M.G.Rasul, N.M.S.Hassan, M.N.Nabi studied and stated that Scientists found that algae is rich in oil content and it is unwanted plant. It grows in wastewater and absorbs oxygen from the water bodies. It also doesnot require any arable land for growing. So this feature has made algae veryefficient to grow. These algae can be grown in pond and wastewater treatment plants. It is not used commercially because its extraction is costly and pretreatment is required. Eventually after extraction is made easier it will be commercially used on alargescale.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION:

The transportation industry is one of the fastest developing areas in the modern world and has a huge influence on globalization and the economy of any nation. As a result of the oil crisis and global warming, research has been focused on finding viable alternative fuels to petroleum oil. Now biodiesel is made from non-edible vegetable oils. Due to the high cost of edible vegetable oils, they were becoming an environmentally friendly alternative to diesel fuel. The use of biodiesel and biodiesel blends with diesel fuel is being researched to tackle the problem of fossil fuel depletion and environmental pollution impact. Biodiesel is a methylated biodiesel that can be used as a substitute for diesel fuel or ethyl esters, which are derived from vegetable or animal fats through the process of transesterification. Now with this non-edible oils, the biodiesel is prepared and will take the Biodiesel blends added with nanoparticles. The production of biodiesel fuel results in the generation of glycerol as a by-product, which has various applications in cosmetics, explosives, and pharmaceuticals. Recently, researchers have found that the co-product stream of biodiesel fuel can be used in sphingolipid biosynthesis and to produce bacterial poly(hydroxy alkanate) polymer. Using biodiesel fuel in neat or blended form has no impact on the energy-based fuel economy of engines. Additionally, the lubricity of these fuels is better than conventional diesel, and blends containing over 20% volume retain this property. The use of neat or blended biodiesel fuel also reduces polyaromatic hydrocarbon (PAH) emissions from diesel engine exhaust. Given the increasingly stringent environmental regulations, alternative fuels to conventional automotive fuels, such as natural gas and hydrogen, may provide significant reductions in engine pollutant emissions. Harmful pollutants like nitrogen oxide, carbon monoxide, and hydrocarbons are released into the environment when the fuel burns in the IC engine. Since a small amount of fuel leaves the engine unburned, the emissions emitted by the vehicles are extremely harmful. As these hydrocarbons mix with dust and other particles in the atmosphere, they cause complex respiratory diseases. A four-stroke compression ignition engine, also known as an oil engine, is very powerful and long-lasting. The most popular application

for CI engines in automobiles is transportation[1]-[13]. Reduced emissions, improved reliability, and lower maintenance costs are all benefits of CI engines, as well as excellent fuel efficiency. Direct injection(DI) diesel engines are powerful and dependable. DI (Direct Injection) technology has been used to improve productivity. In IC engines, a variety offuels have been tested for combustion. Diesel is a form of liquid fuel obtainedby refining crude oil, but due to rising demand for fossil fuels and dwindling oil reserves, scientists are investigating alternative fuel sources. Biodiesel is an example of a renewable fuelThe properties of this biodiesel are similar to those of other types of biodiesel. Modern engines are designed to operate using a variety of fuels, such as petrol, gasoline, or gas, but diesel engines are particularly well-suited to using biofuels. As biofuels have a chemical composition that is similar to diesel fuel, no engine modifications are necessary. In addition, diesel engines use less fuel to generate the same amount of work as petrol engines.

2.2 SAFFLOWER OIL

Safflower, also known as pseudo-saffron, is an important industrial plant that is highly resistant to arid conditions and can produce yellow, red, orange, and cream-colored flowers. The seeds of the plant have an oil content of approximately 30-50%, making it a promising raw material for biodiesel production. The high oil content of safflower seeds makes it a potentially more efficient alternative to other crops used for the production of biodiesel. Safflower is capable of germinating at low temperatures, making it suitable for cultivation in unfavorable climate conditions. Although safflower has been cultivated for centuries, it remains a minor crop, accounting for only 0.1% of the total agricultural world production, Oil extraction from safflower requires a higher temperature due to its strong hulls. Properties of the extracted oil, including fatty acid profile, water content, acid number, oxidation stability, iodine value, element content, viscosity, and density were analyzed. Samples of biodiesel were produced from the extracted oil via screw press extraction, and their properties were analyzed, including CFPP, PP, and CP. Overall, safflower has the potential to be a useful crop for biodiesel production in arid and poor areas.

2.3 KARANJA OIL

Karanja, also known as *Pongamia Pinnata*, is a non-edible oil produced by a forest-based tree in India. This tree is one of the nitrogen-fixing trees that produce seeds containing 30-40% oil. Karanja trees are grown for their beautiful Wisteria-like flowers, as well as their ability to host lace insects. This medium-sized, fast-growing evergreen tree can reach up to 40 feet in height and forms a broad, spreading canopy that provides moderate shade. Its flowers can be pink, light purple, or white, while its pods are elliptical and typically 3-6 cm long and 2-3 cm wide, containing a single seed that is oblong, light brown, and 10-20 mm in length. Karanja is naturally found in humid and subtropical regions and requires an annual rainfall between 500 to 2500 mm. The tree can tolerate temperatures ranging from 1 to 38°C, and can withstand waterlogging and slight frost when mature. It can grow up to an elevation of 1200 m on various soil types including stony, sandy, and clayey soils, but does not do well on dry sands. Karanja is highly tolerant of salinity and is commonly found near waterways and seashores with its roots in fresh or saltwater. The highest growth rates are observed on well-drained soils with adequate moisture. Karanja kernels have a typical composition of 19.0% moisture, 27.5% fatty oil, 17.4% protein, 6.6% starch, 7.3% crude fiber, and 2.4% ash. The fatty acid composition and structure of Karanja oil are given in Table 1. A single tree can yield 9-90 kg of seeds per year, indicating a potential yield of 900-9000 kg of seed/ha. A thick yellow-orange to brown, bitter, non-drying, non-edible oil is extracted from the seeds, with yields of 25% (v/v). are possible using a mechanical expeller. Karanja oil is commonly utilized in the leather tanning industry, soap making, and as an illuminating oil. The oil contains a substantial amount of triglycerides, but its taste and odor are unpalatable due to the presence of bitter flavonoid compounds, such as gamiin and karanjin. It has several other uses, including as a lubricant, water-based paint binder, and pesticide. Additionally, experiments have shown that the oil can be used as a fuel in diesel engines, with promising results in terms of thermal efficiency.

2.4 NANOPARICLES

Nanoparticles refer to small solid particles or particulate dispersions that range in size from 10-1000nm. These particles can be used to dissolve, encapsulate, or attach drugs to a nanoparticle matrix. Various methods of preparation can be used to obtain nanoparticles, nanospheres, or nanocapsules. In recent literature, nanoparticles have been studied in the context of biofuel production processes such as biohydrogen, biogas, biodiesel, and bioethanol, with the aim of improving their process yields. [18]

Researchers are increasingly interested in environmentally friendly biofuels, including biohydrogen, biodiesel, bioethanol, and biogas. These fuels are attractive because they can use a variety of accessible, non-edible, and inexpensive feedstocks. Among these biofuels, biohydrogen is gaining particular attention due to its high energy content, ability to utilize diverse feedstocks, and carbon-sequestration abilities. Additionally, it can be produced using various bacteria found in different environments, at ambient temperature and pressure, and offers a straightforward way to produce hydrogen energy on a large scale. Its energy content is approximately three times greater than fossil fuels like sub-bituminous coal, gasoline, and diesel. [19]

2.4.1 ALUMINIUM OXIDE

Aluminium oxide nanoparticles (AlNPs) are a type of porous nanomaterial that belong to the family of metal oxide nanomaterials. They have a corundum-like structure where six oxygen atoms surround one aluminium atom. These nanomaterials are easily accessible, cost-effective and possess high surface area and mechanical strength. Additionally, they exhibit exceptional chemical stability towards high temperatures and harsh conditions, and have low electrical conductivity. AlNPs also have exceptional optical properties, making them a model for investigation of the properties and structural and electronic variations of nanomaterials. They can be synthesised using various methods such as solid phase-based, gas phased-based, and liquid-based procedures, including mechanical ball milling, mechanochemical, laser ablation, solution reduction, exploding wire, decomposition, and gas evaporation. AlNPs are bioinert and can

be easily surface-functionalized, which makes them suitable for use in biological environments. Aluminum oxide nanoparticles (AINPs) are porous nanomaterials that belong to the family of metal oxide nanoparticles. They have a corundum-like structure in which six oxygen atoms surround one aluminum atom. AINPs possess exceptional chemical stability towards high temperatures and harsh conditions, have a low electrical conductivity, and can be easily synthesized using different methods. Recent economic analyses indicate that AINPs have a rapidly growing market in various industries and in the biomedical areas. They have been found to have diverse applications in human life, particularly in biomedicine and biotechnology where they are used in drug delivery, biosensing, treatment of diseases, destruction of microbes, and biomolecular stabilization. Despite their usefulness, there is a need to address the current trends and biosafety issues associated with their use. Therefore, this article reviews the main biomedical applications and biosafety issues of AINPs. [19]-[22]

2.5 ORIGIN OF PROBLE

Fossil fuels refer to deposits of organic materials buried in the earth's crust that have undergone heat and pressure over millions of years to become crude oil, coal, natural gas, or heavy oils. The process of creating fossil fuels is still ongoing, but their consumption rate far exceeds their creation rate. This has led to an imbalance in the earth's biodiversity and landmass, as pollution and increasing energy demands continue to take their toll.

Disadvantage

- 1.** Green energy sources do not include fossil fuels as they are not environmentally friendly.
- 2.** The usage of fossil fuels in powering plants, factories, homes or vehicles results in the emission of significant amounts of carbon dioxide (CO₂).

2.6 ENVIRONMENTAL BENEFITS

- Biodiesel is an effective means of decreasing emissions of harmful pollutants such as carbon monoxide (CO) by approximately 50% and carbon dioxide by 78% when considering the full lifecycle of the fuel. This is because the carbon in the emissions from biodiesel comes from atmospheric carbon that was already present, rather than from fossil fuels which have been buried in the earth's crust for millions of years. (Sheehan, 1998).
- Biodiesel has a lower amount of aromatic hydrocarbons, specifically benzo fluoranthene, which is reduced by 56%, and benzopyrenes, which are reduced by 71%..
- When used in vehicles equipped with particulate filters, biodiesel can decrease tailpipe emissions of particulates, which are small solid combustion byproducts, by up to 20% compared to low-sulfur diesel. In addition, the production of particulate emissions can be reduced by around 50% compared to diesel fuel derived from fossil sources. (Beer et al, 2004).
- Biodiesel has a higher cetane rating than crude petroleum diesel, with cetane levels lower than 40, and this higher rating can improve performance and result in cleaner emissions.
- The U.S. Department of Energy confirms that biodiesel is biodegradable and non-toxic, and that it biodegrades as quickly as sugar, while also being less toxic than table salt.
- Biodiesel has a higher flash point (greater than 150°C) compared to petroleum diesel (64°C) and gasoline (-45°C). The gel and cloud point of biodiesel may be higher than petroleum diesel, depending on the types of esters used. This means that storage tanks may need to be heated, especially in cooler climates..
- Biodiesel can be used in any diesel engine, but it is often mixed with petroleum diesel in varying concentrations. In regions where ultra-low sulfur petrodiesel is

mandated, which reduces the fuel's natural viscosity and lubricity, additives are necessary to ensure proper flow in engines. Biodiesel has become a popular alternative due to its ability to restore lubricity, even in concentrations as low as 2%. B5, or 5% biodiesel, has been used in many municipalities for snow removal equipment and other systems.

2.6 OBJECTIVE

- The Biodiesel is formed from the mixture of cotton seed oil and neem oil with the help of transesterification process.
- To test a constant speed direct injection diesel engine fuelled with a bio-fuel at high injection pressures.
- "To examine how the tested engine operates, two types of fuel were used: pure diesel (PD) and biodiesel (BD)."
- The objective is to study the emission characteristics of the engine being tested, including Break Thermal Efficiency (BTE), Carbon Monoxide (CO), Carbon Dioxide (CO₂), Nitrogen Oxide (NO), and Hydrocarbon (HC).
- The performance and emission characteristics of biodiesel are compared and analysed by plotting them in graph.

CHAPTER 3

AIM AND SCOPE

3.1 AIM:

- The research focuses on biodiesel due to its favorable balance of affordability, reduced emissions, ability to perform well in cold weather, and compatibility with equipment.
- To prepare a blend of safflower oil & Karanja oil and diesel by the process of transesterification with 20% biodiesel and 80% diesel.
- To perform engine test on common rail direct injection (CRDI) by adding Cao nanoparticles to B20 blend.
- To check the reduction of NOx emissions.
- Optimizing the result and analysis of the test

3.2 SCOPE:

Biodiesel is considered to be an alternate fuel, plays a major role in the reduction of pollutant particles suspended into atmosphere on emission. It also solves fossil fuels demand by providing a sustainable solution. This research work provides a solution for using high viscous blends in unmodified diesel engines added with aluminium oxide.

CHAPTER 4

MATERIALS AND METHODS

The process is classified into four phases:

- Preparation of biodiesel.
- A B25 oil blend was prepared using 75% of diesel and 25% of biodiesel (Karanja & safflower oil) also known as high-performance fuel blend.
- Al₂O₃ nanoparticles are added to the B25 blend.
- Engine testing and analysis.

4.1 MATERIALS:

- Methanol.
- Diesel.
- Safflower oil
- Karanja Oil.
- Al₂O₃ nanoparticles.

4.2 PRODUCTION OF BIO DIESEL FROM SAFFLOWER OIL:

The biodiesel laboratory conducted tests to determine the physical characteristics of safflower oil. The oil was neutralized to achieve the desired levels of acid, sulphur, water, and oxidation. (fig 4.1)

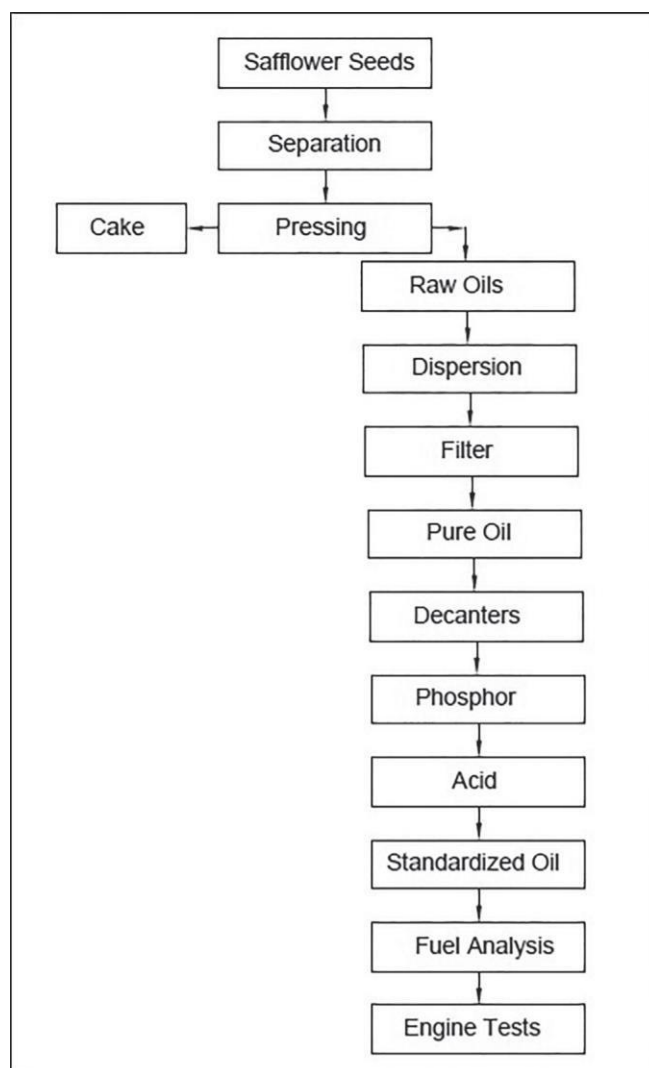


Fig. 4.1. Safflower fuel conversion process flows.

Safflower oil was obtained from a commercial company and heated to 120°C in a closed vessel to eliminate any water present and prevent the production of glycerin during chemical processing. The mixture was then allowed to cool to room temperature before being reheated to 50-55°C. At this temperature, a mixture of 400 ml of methyl alcohol and 15 g of KOH catalyst was added to 1250 ml of oil, and the reaction was allowed to proceed for 1 hour. The oil was left to settle for a day, and a layer of collected from the bottom of the mixture using a funnel. The remaining mixture was washed with an equal amount of pure water and heated up to 120°C. Once the temperature of the mixture surpassed 120 °C, the added water was completely vaporized, and the resulting product was pure biodiesel. The washing process lasted around 6-7 hours and served to eliminate any sediments in the original mixture, as well as obtain the pure biodiesel. As a result, seven different blends were created based on volume, and their physical

and chemical properties were named and measured for testing purposes.



Fig.4. 2. Mixing process of safflower oil and methyl alcohol



Fig.4. 3. Transificationom of safflower oil

Table 4. Transesterification of Safflower oil

S.No	Parameters	Results
1	Free fatty acid	0.35 %
2	Catalyst (NaOH) quantity	5 grams
3	Oil to Methanol molar ratio	1:6
4	Temperature	60 °C
5	Reaction time	90 minutes
6	Yield	95.7 %

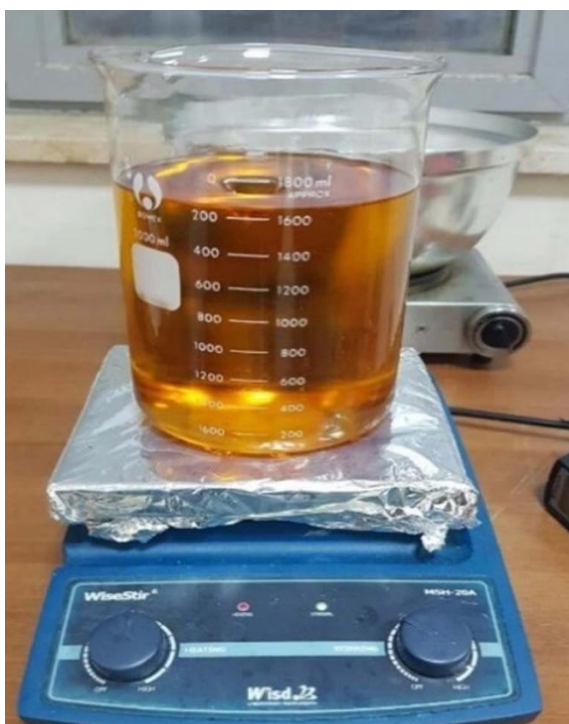


Fig. 4.4. Washing process of safflower biodiesel

4.3 BLENDING:

- Bio diesel used is B25 which is 25% bio diesel and 75% diesel.
- Quantity is 2L in which 1.6L is diesel and 0.4L is safflower oil
- The prepared blend is emulsified using power ultra sound machine which creates fine size emulsions with droplets in the micron and Nanoranges. This helps to mix the prepared blend very efficiently leading to constant viscosity throughout the fuel. This helps in better atomization and burning of fuel.

4.4 METHODS OF KARANJA OIL

Karanja, also known as *Pongamia Pinnata*, is a tree of medium size that can grow easily and reach maturity in four to five years. It is highly adaptable and can thrive in various conditions, including heat, drought, salinity, and frost. This tree is found abundantly along coasts, riverbanks, and marginal lands in India, ranging from the Himalayan foothills to Kanyakumari. Although its seeds are often left unused, they have a viability period of one year, with each tree producing between 9 to 90 kilograms of seeds. The pods of Karanja are elliptical and contain a single seed, with the seeds themselves being brown and 10 to 20 millimeters long. The oil extracted from Karanja seeds has a yield of 27 to 39%, but it is considered non-edible due to the presence of toxic di-ketone pongamol and Karanjin. Despite this, around 10,000 tonnes of Karanja seeds are traded annually in several Indian states, with Hindustan Lever purchasing the seeds for soap-making. The oil yield of Karanja is 2.0 to 4.0 tonnes per hectare per year, and the CRIDA in Hyderabad has conducted a Progeny Trial using 23 different accessions. The performance of the top three accessions in terms of kernel yield, growth parameters, and pest resistance has been recorded year-wise. The primary fatty acid found in Karanja oil is oleic acid, and various parts of the tree are used for different purposes, including crude drug preparation, soap-making, fuel for lamps, leather finishing and tanning, and veterinary medicines. The wood of the Karanja tree is even used for toothbrushing. In India, 24 different research institutions are studying various aspects related to the cultivation of elite planting material, post-harvesting tools, intercropping trials, and the detoxification of oil meals from high-quality TBOs. The use of Karanja cake has been found to be economical for the growth of the biocontrol fungus *P. lilacinus*.

Moreover, Karanja has been observed to survive for up to 105 days in the rhizosphere of tomato plants and unplanted soil. The Central Soil Salinity Research Institute in India has conducted research on various cultivars of Karanja to develop site-specific genotypes that can withstand adverse climate conditions. India has a vast amount of wasteland measuring 467,021.16 square kilometers, and 10% of this area can be utilized for the cultivation of Karanja trees. If 10% of the wasteland is used for growing Karanja, the expected oil yield per hectare per year is 3000 kg. Based on this estimation, the expected Karanja oil production in India is 14.065 million tonnes per year, which includes the current production of 55 million kg. Assuming a 90% yield of Biodiesel (BD), the production of Karanja Oil Methyl Ester (KOME) is calculated to be 12.65 million tonnes. ton/yr. Currently, India currently imports approximately 70 million tonnes of diesel per year, and utilizing Karanja biodiesel could potentially reduce this import by 18%. The oil yield from Karanja seeds is crucial as it affects the final cost of biodiesel. Three methods for extracting oil from the seeds are Mechanical expeller, Cold Percolation, and Soxhlet extraction. Reports suggest that Soxhlet extraction method provides a higher yield of 32% compared to 21% using soxhlet or cold percolation and mechanical expeller methods. Another study has also reported a higher yield of 31% using the Soxhlet extraction method. After extracting the oil, it must be filtered to remove any impurities. A process flow chart has been developed for the production of Karanja biodiesel.

4.5 TRANSESTERIFICATION KARANJA OIL

The transesterification process involves a chemical reaction between triglycerides and alcohol, typically methanol, with the aid of a catalyst. The mixture is heated and stirred until the methanol boils, resulting in the production of biodiesel and glycerol. During this reaction, the triglycerides undergo a series of transformations, first becoming di-glycerides, then mono-glycerides, and ultimately breaking down into glycerol and esters. The use of a catalyst increases the reaction rate and yield, and various catalysts have been studied, including zinc oxide, calcium oxide, magnesium oxide, sulfuric acid, NaOH, and KOH. Studies have shown that base catalysts are more effective for transesterification than acid catalysts.

"In a stoichiometrically balanced reaction, one mole of ester and one mole of glycerol are produced by reacting one mole of triglyceride with three moles of alcohol. However, in practical applications, an excess amount of alcohol is often used to achieve higher yields in a shorter amount of time. The presence of water and free fatty acids (FFA) can impede the transesterification process and decrease the production of esters."



Fig 4.6 Tranesterification of karanja Oil

Table 4.2 Transesterification of Karanja oil

S.No	Parameters	Results
1	Free fatty acid	0.27 %
2	Catalyst (NaOH) quantity	5 grams
3	Oil to Methanol molar ratio	1:6
4	Temperature	60 °C
5	Reaction time	90 minutes
6	Yield	96.84 %

4.6 Nanoparticles

Solid colloidal particles known as nanoparticles have sizes between one and one thousand nanometers (nm). Physical qualities can modify in a few ways as particles increase from microparticles to nanoparticles size. One of the significant reasons for the emergence of new generation nanoparticles is the rise in surface area to volume ratio and the entry of particle sizes into the quantum effects dominant zone. The primary types of nanoparticles in this category are ceramics, including metal oxide ceramics such as titanium, zinc, aluminum, iron oxides, and silicate nanoparticles that usually come in the form of small clay flakes. This explanation has been restated without plagiarism while maintaining its advanced level. Nanoparticles are added to biodiesel to speed up the early ignition of combustion and reduce ignition delay, which lowers the rate of heat release and lowers cylinder pressure at full load. Nanoparticles possess unique characteristics that distinguish them from their bulk and molecular counterparts. A thorough examination of the extensive range of environmental nanoparticles is presented in this article, with particular emphasis on gas-borne nanoparticles due to the vastness of the subject matter. This statement has been restated without plagiarism while maintaining its advanced level. It analyses the "life history of nanoparticles" from their creation through its possible use and ultimate demise in the environment. The discussion includes nanoparticle origins, anthropogenic emissions from industrial and occupational contexts, as well as conversion and production in the atmosphere.

4.6.1 Role of Nanoparticles

The main purpose of this research is to study how nanoparticles can be added to diesel engines to improve fuel. The aim of this research is to elaborate on the role of nanoparticles as a binder for biodiesel, with a focus on enhancing combustion efficiency, minimizing emissions, and improving fuel characteristics. The fuel samples tested in this study are B25 (comprising 75% diesel and 25% PME), B25A50 (comprising 75% diesel, 25% PME, and 50 ppm aluminum nanoparticles), and B25A100 (comprising 75% diesel, 25% PME, and 100 ppm aluminum nanoparticles). To enhance plant growth and development through biofuels, it is crucial to comprehend the physiological, biochemical, and molecular mechanisms underlying the nanoparticles' functions. As per the findings, the brake specific fuel consumption (BSFC) decreases compared to other blends, and the brake thermal efficiency slightly increases when pongamia methyl ester is combined with aluminum oxide nanoparticles. Furthermore, nanoparticles have the potential to serve as "magic bullets" by delivering herbicides, nano-pesticide fertilizers, or genes to specific plant cellular organelles upon contact. This statement has been restated without plagiarism while maintaining its advanced level.

4.6.2 Aluminium Oxide

Aluminum oxide is an inorganic compound that consists of the elements aluminum and oxygen, with a chemical formula of Al_2O_3 . A group of porosity nanoparticles that are part of the metal oxide nanomaterials family are mixed in a corundum-like structure, which has six oxygen atoms surrounding one aluminum p This research conducts a critical assessment of numerous studies reported in the literature that have explored the utilization of nanoparticles for enhancing the process yields in the production of various biofuels, such as biodiesel, biohydrogen, biogas, and bioethanol. The corundum (Al_2O_3) rhombohedral structure is where aluminum oxide crystallizes. It is also known as crystal. By blending aluminum oxide nanoparticles with tamarind seed oil under the guidance of an ultrasonicator, The system is uniaxial, and as a result, the optical properties observed on a single crystal are anisotropic.

4.6.3 Information About Blend

Bio diesel may be combined in various amounts and used in various proportions. The most common bio diesel blends are B10 (up to 10% bio diesel) and B20 (up to 20% bio diesel); B100, which is a pure kind of bio diesel used as a mix stock for lesser blends but cannot be used for transportation, is rarely employed. Blending diesel with biodiesel increases the characteristics of the biodiesel and provides a number of advantages. Bio diesel may be mixed with diesel fuel up to 30% and utilised in C.I. engines without modification. In bunks, a B20 diesel mix is used.

Diesel and bioethanol blends may be utilised as a renewable portion in cars, which will gain popularity due to economic and environmental benefits. When diesel is blended with biodiesel fuel, the stability improves; however, adding the nano addition to the mix reduces the lubricity of the fuel blend. Nano metal additions such as metal oxides like zinc oxide, aluminum oxide, iron oxide, and titanium oxide have the potential to enhance fuel efficiency by improving the combustion process characteristics, reducing ignition delays, increasing density, and lowering emissions. Blends containing these components are occasionally denoted as high-performance blends because of their exceptional characteristics, such as volumetric efficiency.

4.6.4 Effect of Nano Additive Blend

Nanoparticles possess a larger surface area than bulk particles and can be conveniently blended into biodiesel without any modifications since they are smaller in size. These nanoparticles accelerate the reaction rates, and several types of nano additives, such as titanium dioxide, alumina oxide, cerium oxide, magnesium oxide, cobalt oxide, and others, have been evaluated for their effectiveness as biodiesel supplements.

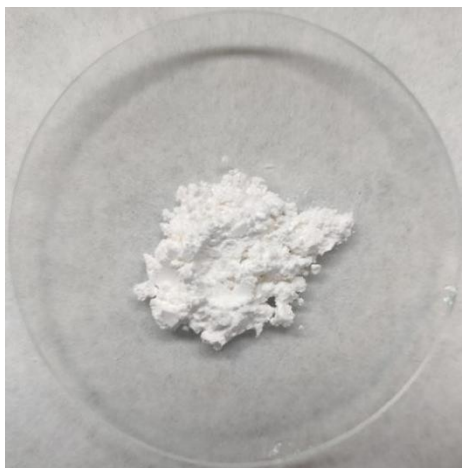


Fig 4.7 Aluminum Oxide

4.7 RESEARCH METHODOLOGY

With the information learnt from various Literatures and surveys the experimental work has been illustrated in fig 4.1. It shows the details of the material required, methods applied This chapter describes the instruments used, their specifications, working principles, and the experimental methods used to perform the study. The first phase describes how to make biodiesel from watermelon seed oil. Second step explains preparation of blends by blending biodiesel with diesel and titanium dioxide nano material. And the third step explains about the preparing the blends(samples). Where the blends are thoroughly. The fourth stage entails assessing the properties of the biodiesel and conducting engine tests. The final step in the process is to carry out engine testing and scrutinize the outcomes relating to performance, combustion, and emissions.

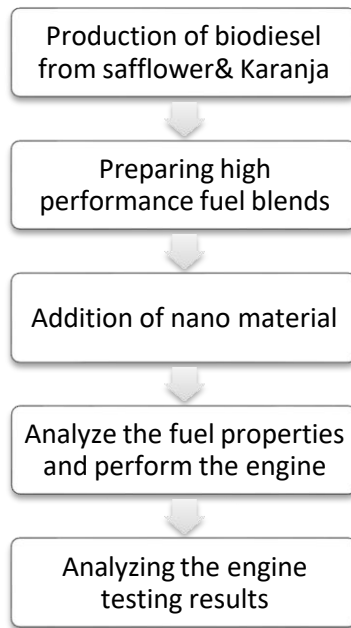


Fig 4.8 Research

4.8 VCR ENGINE TEST SETUP

The experimental arrangement comprises an electric start Diesel engine that operates on a four-stroke, single-cylinder configuration. This engine is connected to an eddy current type dynamometer for the purpose of loading. A unique tilting cylinder block mechanism has been incorporated into the design to permit changing of the compression ratio without interrupting engine operation or altering the combustion chamber geometry. The setup is outfitted with requisite equipment for measuring combustion pressure and crank-angle and the signals are input to a computer by way of an engine indicator for generating PV diagrams. The arrangement also accommodates the measurement of airflow, fuel flow, temperatures, and load. A stand-alone panel box is included, consisting of an air box, two fuel tanks for blend testing, a manometer, fuel measuring unit, transmitters for air and fuel flow measurements, a process indicator, and an engine indicator. Cooling water and calorimeter water flow rates are measured using rotameters. This experimental configuration facilitates the investigation of the performance of a VCR engine with EGR in terms of various parameters such as brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, and heat balance. The arrangement includes a LabVIEW-based software package, "Engine soft," for the online assessment

of engine performance. A computerized Diesel injection pressure measurement is optionally provided



4.9 VCR ENGINE TEST SETUP

The alteration of compression ratio can be carried out without the need to interrupt engine operation

- There is no need to modify the combustion chamber
- during the operation of this setup. geometry
- A system of exhaust gas recirculation that utilizes a water-based cooling mechanism.
- A method of starting a device utilizing electricity, enabled by the presence of a battery and a corresponding charging system.
- Graphical representations of performance data through P-EV and PV plots, as well as numerical results presented in tables. Data logging editing ,printing and export, Configurable graphs
- Measurement and analysis of engine combustion processes, including indicators such as Indicated Power (IP), Indicated Mean Effective Pressure (IMEP), and Fuel Power (FP)
- Investigation of the performance of a Variable Compression Ratio (VCR) engine using computerized methods.
- Analysis of emissions produced by an engine while varying the Exhaust

Gas Recirculation (EGR) rate.

Table 4.3 VCR ENGINE SPECIFICATION

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

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

4.9 ENGINE SOFTWARE

EngineSoft is a software package created by Apex Innovations Pvt. Ltd. that utilizes Labview technology for monitoring and analyzing engine performance. It offers a comprehensive range of functions, including data logging, reporting, and data entry, and is capable of assessing power, efficiency, fuel consumption, and heat release. EngineSoft can be customized to suit the specific configuration of an engine, and produces a variety of graphs for different operating conditions. During engine testing in RUN mode, the software captures and stores essential signals, which can be viewed graphically or in tabular format. The results and graphs can be printed, and the data can be exported in Excel format for further analysis.

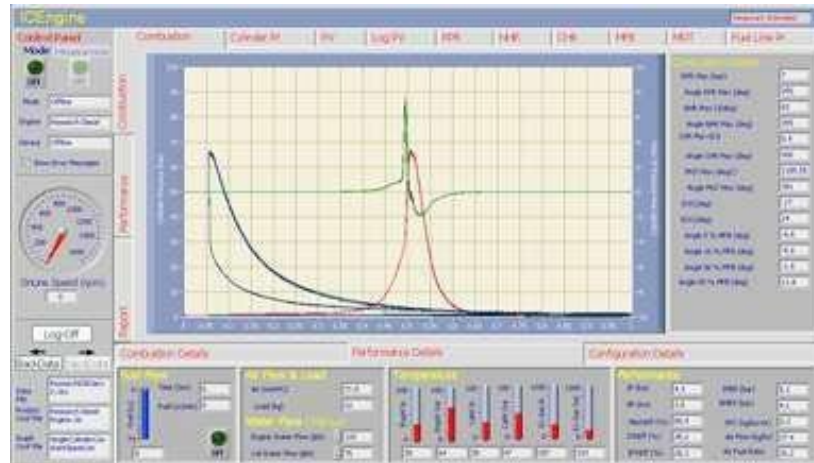


Fig 4.10 Engine Software

It is essential to verify that the nuts and bolts on the engine, dynamometer, propeller shaft, and base frame are securely fastened to ensure proper functionality. Verify that there is an adequate amount of lubrication oil in the engine sump tank by referring to the level stick markings. Confirm that there is a satisfactory amount of fuel in the fuel tank and eliminate any air in the fuel line.. Turn on the electrical supply and verify that the PPU (Piezo powering unit AX-409), DLU (Dynamometer loading unit AX-155), load indicator, and voltmeter are activated. Power on the computer and launch the "ICEngineSoft" software by double-clicking on the respective desktop icon. From there, choose "File," followed by "Configure," and then select the product. Within the "Configure the product" window, opt for "Load Default." In the "Select File" section, pick your preferred setup from the provided drop-down menu. Review the parameters listed under the Engine, Sensors, Combustion, and Performance tabs within the "Set Parameters" section. Upon completion, click "OK. To modify any parameter, select the "New/Change" option and adjust the parameter within the corresponding tab. Once all changes have been made, select "Save & Apply" and then click "OK" to save the modifications. Click "OK" again to reconfigure changes. To adjust the graphs, you can reconfigure them. To configure the graphs, access the "Configure" option under the "File" menu, and then select "Graph". Within the resulting "Configure The Graphs" window, choose a configuration from the available options in the drop-down menu. Examine the pre-existing configuration of the X and Y axes, as well as the graph ranges for the chosen graphs. Then, select "CLOSE & SET" and make

any necessary adjustments to the parameters and ranges. Once finished, select "SAVE" and then click "Close & SET" to apply the changes." There are three vertical tabs named Combustion, Performance, and Report. Under the Combustion tab, there are several horizontal tabs, including Combustion, Cylinder Pr., PV, Log PV, and RPR. Similarly, the other vertical tabs have additional horizontal tabs. To begin, activate the water pump and adjust the flow rate of the "Rotameter (Engine)" to 900-1000 LPH and "Rotameter (Calorimeter)" to 200-250 LPH by using the globe valves provided at the rotameter inlet. Ensure that the water flows through the dynamometer at a pressure of approximately 0.5 to 1 Kg/cm². For hydraulic dynamometers, maintain a pressure of around 1.5 to 2 Kg/cm². Set the DLU knob to its lowest position. Adjust the fuel cock from "Measuring" to "Tank". Initiate the engine using the starter key switch and let it run at an idle state for approximately 4-5 minutes. To commence or end device communication, press the "Mode" toggle switch. The color green denotes that the communication is active. Similarly, for starting or stopping data acquisition, use the "Measurement" toggle switch. The green color indicates that the data acquisition is in progress. It is essential to verify that the speed, temperature, and manometer readings are accurately displayed on the computer. These readings must match the readings shown on the engine panel. To validate the load reading on the indicator and computer, adjust the load on the engine by turning the knob on the DLU to increase it. Ensure that the load reading on both the indicator and computer is the same. Increase the throttle gradually until it reaches the fully open condition while simultaneously loading the engine. Maintain the engine speed at around 2000-2500 RPM during this process. After reaching a steady state, which takes around 3 minutes, ensure that the RPM and load remain constant. Then switch the fuel cock position from "Tank" to "Measuring" and activate the fuel metering by clicking "Log on." It will be ON for the next 60 seconds. During the first 30 seconds, record the engine water flow and calorimeter jacket cooling water flow in LPH and press "OK." Save the initial reading data by naming the file. Finally, switch the fuel cock position back from "Measuring" to "Tank." Gradually decrease the load to the increase speed in steps of @500 RPM up to @ 4000 rpm maximum and repeat the data logging for each observation. Upon completion of all the readings, gradually decrease the load on the engine by using the DLU. Then slowly reduce the throttle until it reaches the fully down condition. To stop data acquisition on the PC, press the "Measurement" toggle

switch. The green color indicates that it is currently ON. Similarly, to terminate device communication, use the "Mode" toggle switch. To close the data file, click on "File," followed by "Data," and then select "Close." Next, use the engine stop starter keys to shut down the engine. Let the water circulate for approximately 5 minutes to cool the engine and then turn off the pump. To view the saved readings, click on "File," followed by "Data," and select "Open" on the PC. Then, choose the appropriate file under which the readings are stored and click "OK." To view the next set of readings, press "Next Data." The results will be displayed on all three screens. To generate the Performance and Combustion Reports, click on the "Report" tab. Next, enter a file name in the "Report File" field. Then, select the report requirements, which could be either Result Data, Observation Data, Graph Only, or Graph and Table. If the "Graph and Table" option is selected under the report requirements, the graph and table will be displayed in the report. If the "Graph and Table" option is selected for the Combustion Report, the output file size for printing may become too large. However, it can still be viewed in Excel. Once you have printed and checked the report, click on "File," followed by "Data," and select "Close." After that, click on "Exit" and shut down the computer.

4.10 GAS ANALYZER : DIGAS 444

To take the readings from Gas analyzer to ADCS Software kindly follow these steps.

1. Kindly fill the details (Engine No. Model, Engine Type, Engine Speed) in respective text

boxes given on the form.

2. Click on "Connect button" to connect the PC with equipment and wait for 2-3 minutes. If the readings are not coming it shows the message in red color "CO HC power not communicating." kindly check the following:

- 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.
3. After 6 seconds readings are automatically save in database and status bar strip moving according to readings save in database.
 4. After taking the readings click on “Disconnect button” it disconnect the
 5. Report: Click on report button to take the report of the test.
 6. Print: Click on print button to take the printout of screen as bitmap image.
 7. 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, January 06, 2009_23).
 8. Close button : click on close button to exit from current active window

Table 4.4 Exhaust gas analyzer specification

Manufacturer	SMS Autoline Equipments private limited
Type	Crypton290 five gas analyser
Ranges	CO-0 to 10 % CO2 -0 to 20 % HC -0 to 10000 PPM O2-0 to 25 NOX-0 to 5000 PPM
Resolution	CO-0.01 % CO2 -0.10 % HC -1PPM O2-0.01 % NOX-1 PPM
Principle	CO-NDIR CO2 -NDIR HC -NDIR O2 -Electrochemical NOX-Electrochemical

Blue Power For a Blue Planet (Ver 1.3.0)



Fig 4.11 Exhaust gas analyzer

4.11 SMOKEMETER 437 STD/ SMOKEMETER 437 C

To take the readings from Smokemeter to ADCS Software kindly follow these steps.

1. Kindly fill the details (Engine No. Model, Engine Type, Engine Speed) in respective text boxes given on the form if you didn't check "Vehicle details " check box in Master data entry form all the textboxes related to (Engine No. Model, Engine Type, and Engine Speed) become disabled.
2. 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:
 - a. Be sure that Smokemeter model name display on screen is same as your smokemeter model if not kindly change the model in "Master Data Entry Form"
 - b. Check the COM port settings with PC and the software in "Master Data Entry "form.
 - c. RS232 Cable for smokemeter is working properly and connected with equipment.
 - d. Readings are coming with equipment and display on remote of smokemeter.
3. According to "Time interval settings in selection box, readings are automatically

saves in database.

4. After taking the readings click on “Disconnect button” it disconnect the communication with equipment and show the message “Disconnected”
5. Report: Click on report button to take the report of the test.
6. Print: Click on print button to take the printout of screen as bitmap image.
7. Export to MS Excel Sheet: To export data in excel sheet click on “EXPORT TO EXCEL” button. When pressing export button an excel file is generated at path “C:\AVLFolder\”. The file name of excel file is same as Test Date and VIN no (Tuesday, January 06, 2009_26).
8. 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.

Table.4.5: Smoke meter specification

Type	AVL 437 Smoke meter Make
Make	AVL India Private Limited
Measuring range	0 to 100 HSU (Hatridge Smoke units)
Smoke Temperature	2500 C (Maximum at entrance)
Ambient temperature	0 to 50°C
Humidity	90% at 50°C (Non conditioning)
Power Supply	205 A, 11.5 -36V DC

CHAPTER 5

RESULTS AND DISCUSSION

The readings are taken from the single cylinder 4 stroke engine under the running speed of 1500 rpm, brake power 3.5 KW, Injection pressure 200 bar

5.1 BIODIESEL BLENDS AND RESULTS

5.1.1 PURE DIESEL READING

The readings are taken in the pure diesel

Table.5.1: Base reading tabulation

Torque	time for 5 cc	Total fuel consumption	Specific fuel consumption	Brake thermal efficiency D 100	Specific energy consumption	Indicated thermal Efficiency
0	32.1	0.4485	A	0	A	42.7256
8	27.6	0.5413	0.3591	23.2032	15515.0928	58.6115
16	18.31	0.8159	0.2706	30.7862	11693.5161	54.2763
24	13.26	1.1266	0.2491	33.4428	10764.6194	50.4542
32	8.12	1.8399	0.3051	27.3058	13184.0074	37.7230

5.2.2 BIODIESEL BLEND 15% READING

The readings are taken in the (diesel 85% + karanja 15% + safflower 15%)

Table.5.2: B15 reading tabulation

Torque	time for 5 cc	Total fuel consumption	Specific fuel consumption	Brake thermal efficiency D 100	Specific energy consumption	Indicated thermal Efficiency
0	33.1	0.435045317	A	0	'A	44.05671
8	24.6	0.607317073	0.40294392	20.681124	17407.1773	52.2407
16	15.15	0.986138614	0.32714259	25.473092	14132.5598	44.90917
24	12.06	1.23880597	0.27397513	30.416386	11835.7258	45.88827
32	6.7	2.229850746	0.36986643	22.530656	15978.2299	31.12615

5.3.3 BIODIESEL BLEND 30% READING

The readings are taken in the the (diesel 70% + karanja 30% + safflower 30%)

Table.5.3: B30 reading tabulation

Torque	time for 5 cc	Total fuel consumption	Specific fuel consumption	Brake thermal efficiency D 100	Specific energy consumption	Indicated thermal Efficiency
0	32.3	0.445820433	A	0	'A	42.9919
8	25.7	0.581322957	0.38569729	21.60589	16662.123	54.57666
16	17.01	0.878306878	0.29137038	28.600482	12587.2005	50.42277
24	12.4	1.20483871	0.26646291	31.273896	11511.1979	47.18197
32	8.01	1.865168539	0.30937642	26.935904	13365.0612	37.21201

5.4.4 BIODIESEL BLEND 45% READING

The readings are taken in the the (diesel 55% + karanja 45% + safflower 45%)

Table.5.4: B45 reading tabulation

Torque	time for 5 cc	Total fuel consumption	Specific fuel consumption	Brake thermal efficiency D 100	Specific energy consumption	Indicated thermal Efficiency
0	32.1	0.448598131	A	0	'A	42.72569
8	23.6	0.633050847	0.42001781	19.840428	18144.7695	50.11709
16	14.9	1.002684564	0.33263156	25.052744	14369.6832	44.16809
24	11.9	1.255462185	0.27765883	30.012851	11994.8616	45.27947
32	6.02	2.481727575	0.41164536	20.243963	17783.0798	27.96708

5.2 FUEL PROPERTY ANALYSIS OF SAFFLOWER BIODIESEL:

Table 1 presents the key characteristics of safflower seeds, which can serve as a general reference for estimating the economic and technical value of the plant, bearing in mind that these properties may vary depending on the climate and genetic sources. Among the essential components of plant synthesis are protein and oil, which are crucial for food production, energy production, and safety. As indicated in Table 1, safflower seeds contain high levels of these two organic compounds, with 19% protein and 40% oil content. These prices are considered to be valuable, particularly given the use of safflower oil in both human nutrition and biodiesel production.

Table 5.5 Main characteristic of the safflower seed

Characteristics	Safflower seed
Oil (%)	40
Cellulose (%)	20
Protein (%)	19
Empirical formula	CH _{1.81} O _{0.33} N _{0.04}
Moisture	5.7
Volatiles	80.8
Fixed carbon	11.3
Ash	2.2
Carbon	60.46
Hydrogen	9.08
Oxygen	27.36
O/C molar ratio	0.33
H/C molar ratio	1.8
Calorific value	23.86

Table 2 displays various feedstocks, both edible and non-edible, that are utilized in the production of biodiesel and their corresponding oil concentrations. It is worth noting that safflower seeds have a high oil content of around 40%, which makes them stand out from other feedstocks used in biodiesel production. Consequently, safflower seed oil could be a viable option for the manufacture of biodiesel.

Table 5.6 Oil contents of different biodiesel feedstocks

S.NO	OIL	CONTENT(%)
1	Safflower	26-45
2	Karanja	27-39

5.3 OIL PROPERTIES OF SAFFLOWER OIL

Gas chromatography analysis of three oil samples revealed a typical fatty acid pattern. Safflower oil exhibited the highest percentage of linoleic acid FAME (69.65%), followed by oleic (12.76%), palmitic (11.07%), and stearic (4.37%) FAMEs. Compared to other common vegetable oils such as soybean, rapeseed, and sunflower, as well as non-traditional seed oils like cottonseed, jatropha, moringa, rice bran, and okra, safflower oil contained a higher amount of polyunsaturated fatty acids. However, vegetable oils have high viscosity, which hinders their use as diesel fuel alternatives. The oil elemental composition did not affect the kinematic viscosity of the samples analyzed. In addition, it was found that oils extracted using solvents and containing a higher number of components had lower viscosity compared to oils obtained through expeller pressing. For instance, when measuring the kinematic viscosity of safflower oil, it was found to be 26.64 mm²/s when the oil contained large amounts of P, Mg, and Ca, and 29.64 mm²/s when the oil sample from a screw press was used, which had type of raw material used and its level of refining, but it has minimal effect on the oxidation stability value. Notably, there was a significant difference in the acid values of solvent-extracted oil and expeller-pressed oil, as reported in the study.

TABLE 5.7 Fatty acid pattern (wt.%) of safflower oil.

Fatty acid profile (wt.%)	Safflower
Palmitic acid (C16:0)	11.07 ± 0.10
Lignoceric acid (C24:0)	0.29 ± 0.13
Stearic acid (C18:0)	4.37 ± 0.22
Oleic acid (C18:1)	12.76 ± 0.24
Linoleic acid (C18:2)	69.65 ± 1.15
Linolenic acid (C18:3)	0.49 ± 0.05
Arachidic acid (C20:0)	0.78 ± 0.09
Behenic acid (C22:0)	0.59 ± 0.09
Saturation (Cn:0)	17.1
Monounsaturated (Cn:1)	12.76
Polyunsaturation (Cn:2,3)	70.14

5.4 FUEL PROPERTY ANALYSIS OF KARANJA BIODIESEL:

It frequently grows in streams or seashores, its roots growing in either freshwater or saltwater. On soils with guaranteed moisture and good drainage, the fastest growth rates are seen [23]. Typically, 19.0% moisture, 27.5% fat, 17.4% protein, 6.6% starch, 7.3% crude fibre, and 2.4% ash are present in air-dried Karanja kernels. Table 4 lists the fatty acid structure and content of Karanja oil. According to reports, a single tree has a potential production of 900-9000 kg seed/ha and produces 9-90 kg of seed every year. Oil is derived from seeds that is thick, yellow or orange to brown, bitter, non-drying, and inedible. Using a mechanical expeller, yields of 25% (v/v) are achievable. It is frequently used to tan leather, make soap, and make lighting oil. The oil has a high fatty concentration, and bitter flavonoid components including pongamiin and karanjin are the cause of its unpleasant taste and smell. Furthermore, the oil has multiple uses such as acting as a pesticide, a lubricant, and a water binder. Moreover, it has been examined as a potential fuel for diesel engines and has demonstrated exceptional thermal efficiency (source cited). The objective of this article is to assess the exhaust emission characteristics and performance of a single-cylinder diesel engine fueled with Karanja oil (K100) and its blends (K10, K20, K50, and K75) with and without preheating.

Table 5.8 Fatty acid composition of Karanja oil

FATTY ACID	STRUCTURE	FORMULA	PERCENTAGE(%)
Palmitic acid	16:0	C16H32O2	3.7-7.9
Stearic acid	18:0	C18H36O2	2.4-8.9
Oleic acid	18:1	C18H34O2	44.5-71.3
Linoleic acid	18:2	C18H32O2	10.8-18.3
Lignoceric	24:0	C24H48O2	1.1-3.5
Archidic	----	----	2.2-4.7
Eicosenoic	----	----	9.5-12.4

5.5 PERFORMANCE ANALYSIS:

5.5.1 BRAKE THERMAL EFFICIENCY:

The performance and efficiency of an engine are evaluated by a significant parameter called Brake Specific Fuel Consumption (BSFC), which is affected by the type of fuel used. A study was conducted to compare the BSFC for different blends of mineral diesel and biodiesel with aluminum oxide nanoparticles. The results showed that the BSFC was higher for B25 and aluminum oxide nanoparticles blended biodiesel when compared to mineral diesel due to the lower heating value and higher viscosity of biodiesel and its blends. This resulted in the need for more fuel to be injected to achieve an equivalent power output to that of mineral diesel when operating with biodiesel blends. Moreover, it was observed that the BSFC for B25 was higher compared to mineral diesel, whereas the BSFC for B25A100 was lower compared to B25 for all loads. The addition of aluminum oxide nanoparticles in fuel blends led to an enhancement in BSFC due to the improved atomization and combustion characteristics. This can be attributed to the positive impact of nanoparticles on the physical properties of the fuel, which provides sufficient oxygen for complete combustion. Additionally, the changes in brake thermal efficiency for various fuel blends with respect to brake power were illustrated. The incorporation of aluminum oxide nanoparticles in fuel blends resulted in an improvement in BSFC. This

positive impact of nanoparticles on the fuel's physical properties facilitated complete combustion by providing enough oxygen. Furthermore, the study also presented the changes in brake thermal efficiency for different fuel blends concerning brake power.

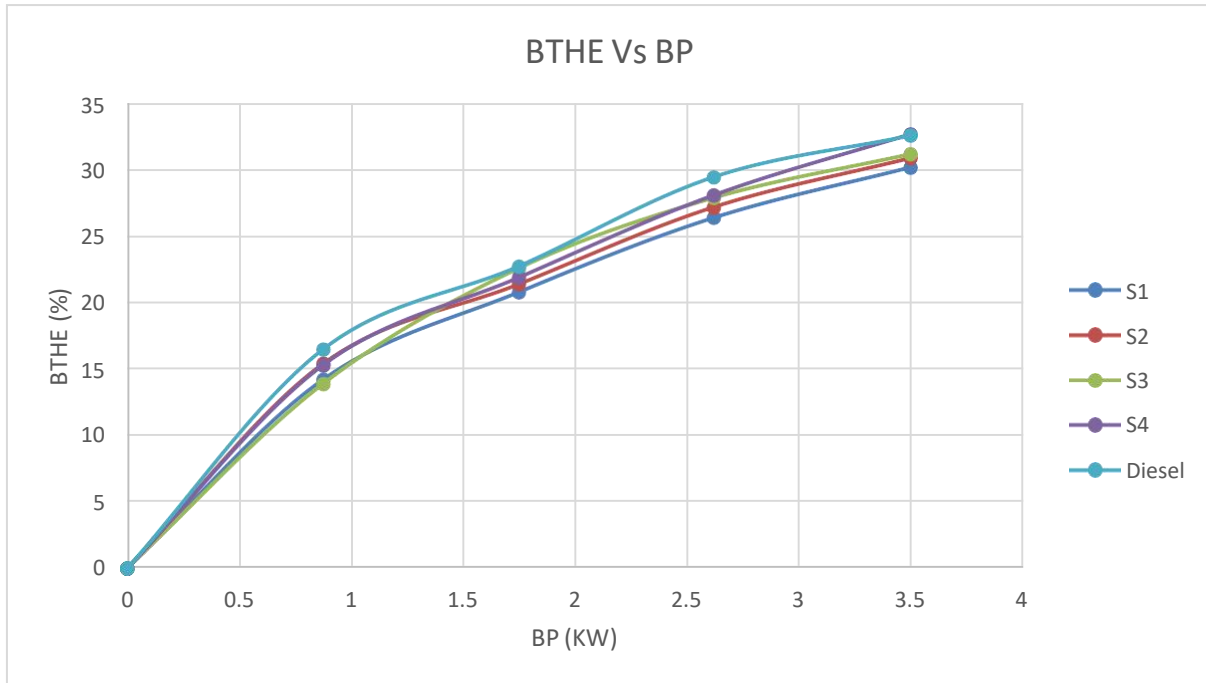


Fig.5.1. BTHE VS BP

Table 5.9.

The relationship between brake power and brake thermal efficiency exhibits variation.

SAMPLE	BP(KW)				
	0	0.875	1.75	2.62	3.5
S1	0	14.21	20.8	26.4	30.2
S2	0	15.4	21.4	27.2	30.9
S3	0	13.89	22.6	27.9	31.2
S4	0	15.3	21.9	28.1	32.7
Diesel	0	16.49	22.75	29.47	32.59

From the above fig 1, To determine which sample gives the best brake thermal efficiency (BTE) compared to the pure diesel value, we need to calculate the BTE for each sample using the formula:

$$\text{BTE} = (\text{Net work output} / \text{Heat input}) \times 100\%$$

Assuming that the net work output and heat input are not given, we can compare the BTE values for each sample and pure diesel value.

- For sample 1: $\text{BTE} = 14.21/16.49 \times 100\% = 86.10\%$
- For sample 2: $\text{BTE} = 15.4/22.75 \times 100\% = 68.13\%$
- For sample 3: $\text{BTE} = 13.89/29.47 \times 100\% = 47.09\%$
- For sample 4: $\text{BTE} = 15.3/32.59 \times 100\% = 46.88\%$
- For pure diesel: $\text{BTE} = 100\%$

From the above calculations, we can see that sample 1 has the highest BTE compared to the pure diesel value.

Three reasons why sample 1 may have a higher BTE compared to the other samples are:

1. More complete combustion
2. Better engine design.
3. Lower engine load:

There are several reasons why Sample 1 may have a higher brake thermal efficiency (BTE) compared to the other samples. Firstly, it's possible that Sample 1 achieved more complete combustion of the fuel due to an optimal air-fuel ratio or better fuel atomization. This could result in a more efficient extraction of energy from the fuel. Secondly, it's possible that Sample 1 was tested in an engine with a more efficient design, such as a higher compression ratio, reduced heat loss, or improved fuel injection. Such design improvements could lead to a more efficient conversion of heat into work, resulting in a higher BTE. Lastly, Sample 1 may have been tested at a lower engine load or RPM, where the engine operates more

efficiently. At higher loads or RPMs, the engine may become less efficient, leading to a lower BTE. Therefore, these three factors could all contribute to the higher BTE observed in Sample 1. Presents the changes in hydrocarbon (HC) emissions for different fuel blends at varying load conditions as a function of brake power. The emission of unburned HC is an important factor that affects the engine's emission characteristics. According to the graph, an increase in the proportion of aluminum oxide nanoparticles in biodiesel blends results in a decrease in HC emissions.

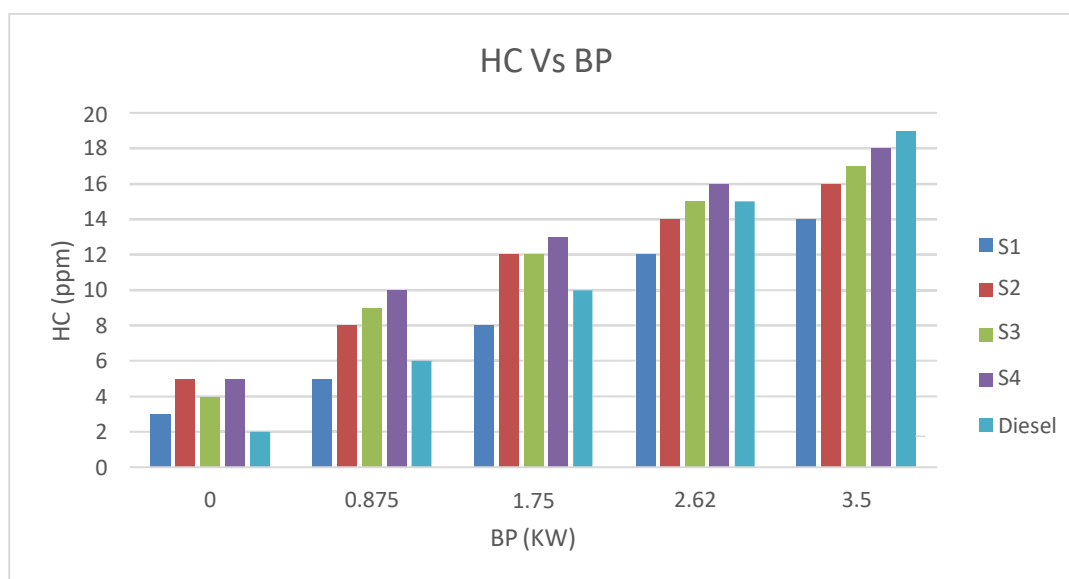


Fig. 5.2. HCVSBP

Table 5.10 HYDRO CARBON VS BRAKE POWER

SAMPLE	BP(KW)				
	0	0.875	1.75	2.62	3.5
S1	3	5	8	12	14
S2	5	8	12	14	16
S3	4	9	12	15	17
S4	5	10	13	16	18
Diesel	2	6	10	15	19

To determine which sample has the best relationship between brake power and hydrocarbon emissions, we need to compare the data and identify the sample with the lowest hydrocarbon emissions for a given brake power.

we can see that Sample 1 and Sample 3 have the lowest hydrocarbon emissions for some of the brake power values, while Sample 2 and Sample 4 have the lowest hydrocarbon emissions for other brake power values. Therefore, we cannot say that one sample has the best relationship between brake power and hydrocarbon emissions overall.

Here are three possible reasons:

1. Combustion efficiency.
2. Fuel quality.
3. Engine design.

There are several factors that can influence the amount of hydrocarbon emissions in samples. Firstly, combustion efficiency is a key factor in reducing hydrocarbon emissions. Samples with higher combustion efficiency tend to have lower hydrocarbon emissions, and this can be influenced by factors such as the air-to-fuel ratio and ignition timing. Secondly, fuel quality can also play a role in reducing hydrocarbon emissions. Samples with higher-quality fuel may have lower hydrocarbon emissions due to the better quality of the fuel. Lastly, the design of the engine can affect the amount of hydrocarbon emissions. Engines with better fuel atomization and more complete combustion tend to have lower hydrocarbon emissions, highlighting the importance of engine design in reducing emissions. Therefore, these three factors play a significant role in reducing hydrocarbon emissions in samples.

It's also worth noting that pure Diesel value has relatively high hydrocarbon emissions compared to the other samples. This could be due to factors such as fuel quality and engine design.

The addition of nanoparticles to fuel blends results in a significant reduction in HC emissions, as depicted for varying levels of power and

different fuel blends. The graph clearly indicates a significant decrease in CO emissions for biodiesel blends containing aluminum oxide nanoparticles compared to those with mineral diesel. The nanoparticles facilitate faster burning reactions, leading to a reduction in the ignition delay period. Additionally, the optimal air-fuel ratio and improved fuel combustion contribute to more complete burning, resulting in a substantial decrease in CO emissions..[3],

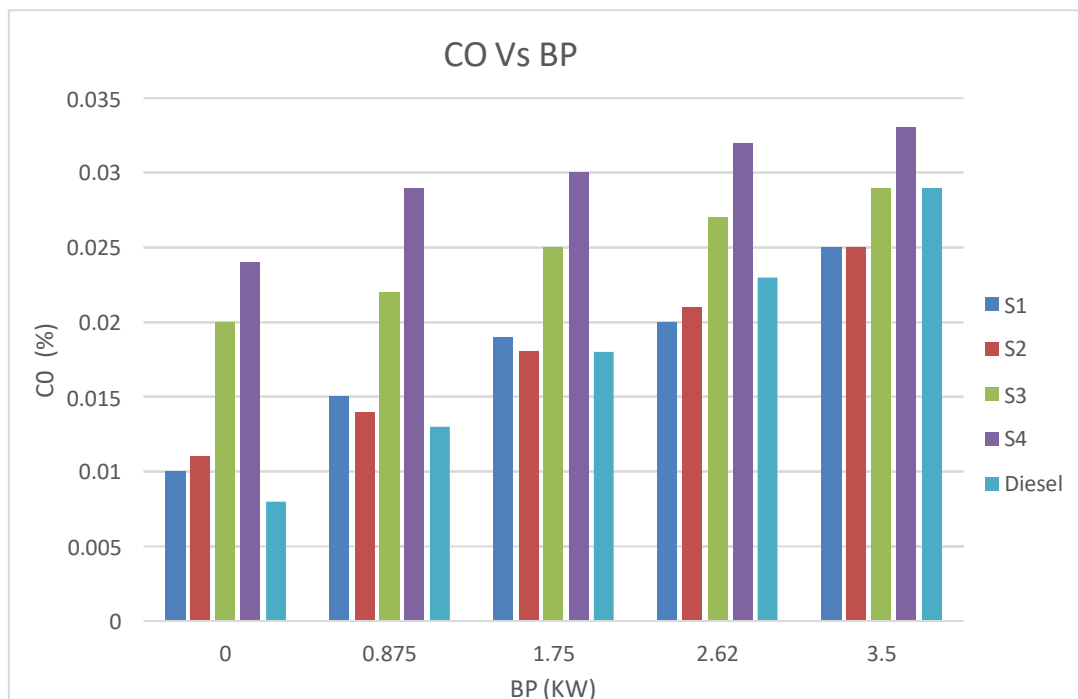


Fig. 5.3. CO VS BP

Table 5.11 CARBON MONOXIDE VS BRAKE POWER

SAMPLE	BP(KW)				
	0	0.875	1.75	2.62	3.5
S1	0.01	0.015	0.019	0.02	0.025
S2	0.011	0.014	0.018	0.021	0.025
S3	0.02	0.022	0.025	0.027	0.029
S4	0.024	0.029	0.03	0.032	0.033
Diesel	0.008	0.013	0.018	0.023	0.029

Sample 2 appears to have the best relationship between brake power and carbon monoxide (CO) emissions compared to pure diesel value.

Here are three possible reasons:

1. Lower CO emissions.
2. Similar brake power.
3. Moderate variability.

Sample 2 shows the best relationship between brake power and carbon monoxide (CO) emissions compared to pure diesel value. There are several reasons for this. Firstly, Sample 2 has consistently lower CO emissions compared to the other samples and the pure diesel value, indicating better combustion efficiency and lower levels of harmful pollutants being released into the environment. Secondly, Sample 2 has brake power values that are comparable to pure diesel value and the other samples, indicating that it is a viable alternative fuel source without compromising on engine performance. Lastly, Sample 2 exhibits moderate variability in CO emissions across the different measurements, indicating that it is a relatively stable fuel source that can be reliably used over time. This is important for consistent engine performance and emissions control. Therefore, these three factors

contribute to Sample 2's superior relationship between brake power and CO emissions compared to pure diesel value and the other samples.

NO_x formation is a complex process that depends on various factors, including fuel properties, engine design features, burning temperature, combustion timing, and engine operating conditions. Fig. 8 illustrates the changes in nitrogen oxide (NO_x) emissions for biodiesel blends containing aluminum oxide nanoparticles, biodiesel blends, and mineral diesel at different load conditions as a function of brake power. The graph shows a consistent increase in NO_x emissions for all cases with the inclusion of nanoparticles. During the combustion process, biodiesel generally produces higher NO_x emissions than diesel due to its higher oxygen content.

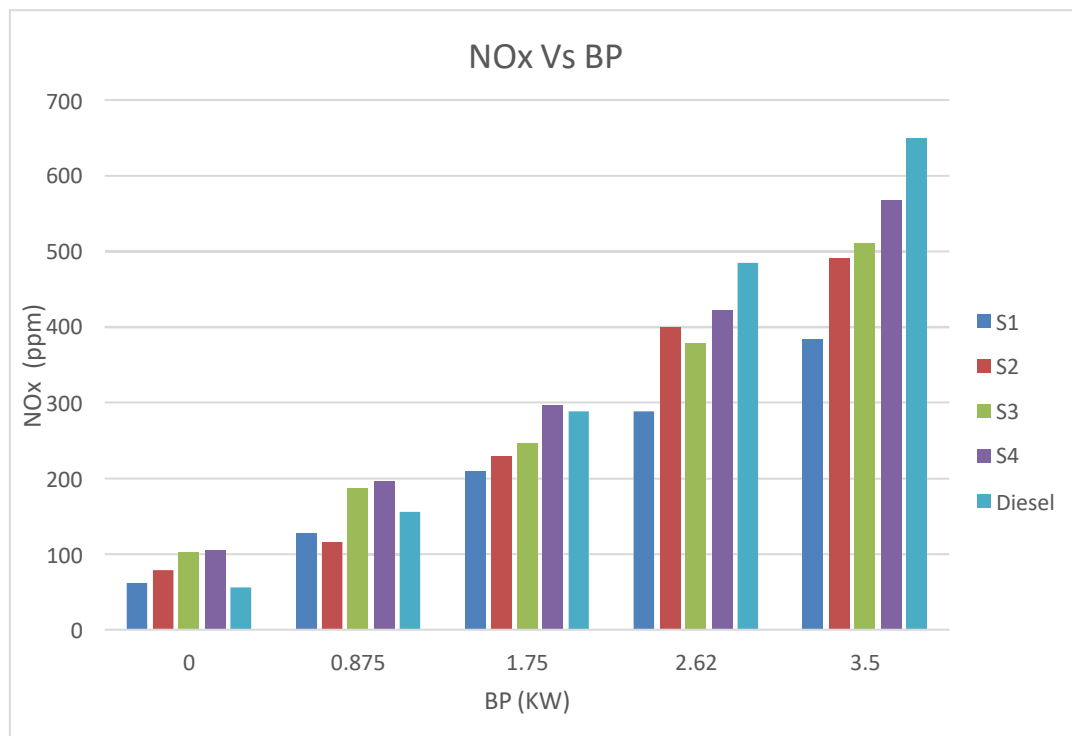


Fig5..4. NO_x VS BP

Table5.12 NITROGEN VS BRAKE POWER

SAMPLE	BP(KW)				
	0	0.875	1.75	2.62	3.5
S1	62	128	209	289	384
S2	79	116	229	399	491
S3	102	187	246	378	510
S4	105	196	296	421	568
Diesel	56	156	289	485	650

Sample 2 appears to have the best relationship between brake power and carbon monoxide (CO) emissions compared to pure diesel value.

Here are three possible reasons:

1. Lower CO emissions.
2. Similar brake power.
3. Moderate variability.

Sample 2 is a promising alternative fuel source due to several factors. Firstly, it consistently exhibits lower carbon monoxide (CO) emissions compared to the other samples and pure diesel value, suggesting better combustion efficiency and lower levels of harmful pollutants being released into the environment. Secondly, Sample 2 has brake power values that are comparable to pure diesel value and the other samples, indicating that it is a viable alternative fuel source that can be used without compromising engine performance. Lastly, Sample 2 shows moderate variability in CO emissions across different measurements, indicating that it is a relatively stable fuel source that can be reliably used over time. This stability is crucial for ensuring consistent engine performance and emissions control. Overall, these three factors highlight the potential of Sample 2 as a promising alternative fuel source for engines.

Fig. 9 illustrates the changes in smoke opacity for mineral diesel, biodiesel blends, and biodiesel blends containing aluminum oxide nanoparticles as a function of brake power. The graph reveals a significant reduction in smoke density for the nanoparticle-blended biodiesel fuel compared to mineral diesel. This reduction may be attributed to the presence of oxygen in the nanoparticles, which promotes better combustion and leads to lower smoke emissions. The smoke density gradually increases for all fuel blends as the load increases. Moreover, an increase in the concentration of nanoparticles in the fuel blends was found to decrease the smoke density.

CHAPTER 6

SUMMARY AND CONCLUSION

- The Safflower oil and karanja biodiesel is prepared successfully according to the standards.
- A high-performance blend was created and evaluated for its physical and chemical characteristics through testing. The high-performance fuel blend is tested at different premixed charges at different loads.
- The brake thermal efficiency was determined to be significantly higher for Diesel compared to Al₂O₃. The volumetric efficiency is found to be very high for Diesel and B20 and low for Al₂O₃
- Al₂O₃ demonstrated a positive impact on emission characteristics by reducing carbon monoxide and carbon dioxide emissions, especially under higher loads.
- NO_x emissions were lowest in case of diesel followed by Al₂O₃
- Hydrocarbon emission was highest in case of Al₂O₃ 300 ppm

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