

Impact of Nano Additives in DI Diesel Enigne By Using Biodiesel Blends with Diesel

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

By

Dharun K (39150032)

Sanchit Kumar T (39150115)



**DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL OF
MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY(DEEMED TO BE
UNIVERSITY)**

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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www.sathyabama.ac.in

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Dharun K (39150032)** and **Sanchit Kumar T (39150115)** who carried out the Final Year Project entitled "**Impact of Nano Additives in DI Diesel Engine by Using Biodiesel Blends with Diesel**" under our supervision from December 2022 to April 2023.

Internal Guide

Dr. J. Senthil Kumar, M.E., Ph.D.,

Head of the Department
Dr. G. ARUNKUMAR, M.E., Ph.D.,

Submitted for Viva voce Examination held on 10-05-2023

Internal Examiner

External Examiner

DECLARATION

We **Dharun K (Reg.No: 39150032)** and **Sanchit Kumar T (Reg.No: 39150115)** hereby declare that the Project Report entitled **“Impact of Nano Additives in DI Diesel Engine by Using Biodiesel Blends with Diesel”** done by me under the guidance of **Dr J. Senthil Kumar M.E., Ph.D** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

1)



2)



DATE: 10.05.2023

PLACE: CHENNAI

SIGNATURES OF THE CANDIDATES

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ABSTRACT

The preparation of an alternative fuel for everyday use is the topic of the project. The gasoline made of hydrocarbons is now quite reliable. All developing and developed nations are talking a lot about the various forms of energy demand in the country. Ecologically sound alternatives, including biodiesel, should be considered. Using blends of diesel and biodiesel with nano additions, the major goal of this experiment is to identify the engine performance and emission parameters of diesel engines. Blends of biodiesel in various ratios are created, and the nano additives titanium oxide (TiO₂) and aluminum oxide (Al₂O₃) are added. Diesel is used as the fuel for the experiment, and biodiesel is blended with nano additives of various sizes in an equal volume. Different amounts of 20 nm and 50 nm nano additives are added to biodiesel in this process. On a single cylinder, direct injection, four-stroke diesel engine, the trials will be carried out. The performance of the fuel and the emission characteristics must be considered when using a diesel engine. Carbon Monoxide (CO), Hydro Carbons (HC), Carbon Dioxide (CO₂), NO_x, Specific Fuel Consumption (SFC), and Brake Thermal Efficiency (BTE) studies will be carried out, and all of these will be compared to Pure Diesel.

The demand for energy is a significant topic in both developing and developed nations. The need for energy is growing rapidly every day. Biodiesel is a viable alternative answer to this issue; hence it is vital to discover an environmentally friendly alternative solution. The primary goal of this research is to evaluate and compare the emissions, combustion behaviors, and performance of diesel engines employing Pithecellobium Dulce. As a catalyst, seed oil biodiesel that has been blended separately and mixed with nanoparticles of titanium oxide and aluminum oxide is employed. Trans esterification was used to esterify Pithecellobium Dulce Seed Oil. Then, for each nano substance, samples S1, S2, and S3 were generated using a sonication technique. The measurement variables are combustion behaviors, specific fuel consumption, break power, and break thermal efficiency.

Keywords: Specific Fuel Consumption, Break Power, Brake Thermal Efficiency, Cylinder Pressure, Net Heat Release Rate

TABLE OF CONTENTS

CHAPTER NO.	TITLE	PAGE No.
	ABSTRACT	v
	LIST OF FIGURES	ix
	LIST OF TABLES	x
	LIST OF ABBREVIATIONS	xi
1	INTRODUCTION	1
	1.1 INTRODUCTION TO BIODIESEL	1
	1.2 BACKGROUND ON BIODIESEL	1
	1.2.1 Definition	1
	1.3 GENERATIONS OF BIODIESEL	2
	1.3.1 The First Generation of Biodiesel	3
	1.3.1.1 Sunflower Oil	3
	1.3.1.2 Soybean Oil	4
	1.3.1.3 Rapeseed Oil	4
	1.3.1.4 Seed of Cotton	5
	1.3.1.5 Palm Oil	5
	1.3.2 The Second Generation of Biodiesel	6
	1.3.2.1 Waste Oil	6
	1.3.2.2 Animal fat	7

	1.3.2.3 Jatropha	7
	1.3.3 The Third Generation of Biofuels	7
	1.3.3.1 Micro Algae	8
	1.4 FEEDSTOCK SOURCES FOR BIODIESEL	8
2	LITERATURE SURVEY	12
	2.1 Summary of Literature Survey	14
3	AIM AND SCOPE	16
	3.1 Aim	16
	3.2 Scope of the investigation	16
4	MATERIALS AND EXPERIMENTAL METHOD	17
	4.1 Materials	17
	4.2 Titanium Oxide	17
	4.3 Aluminium Oxide	18
	4.4 Pithecellobium Dulce Seed Oil	19
	4.5 Methodology	20
	4.6 Transesterification of Pithecellobium Dulce Seed Biodiesel	20
	4.7 Property Testing And Analysis	21
	4.7.1 Characterization of Al ₂ O ₃	21
	4.7.2 XRD Analysis	22
	4.7.3 FT-IR Analysis	23

	4.7.4 FESEM (SEM-EDAX) Analysis	24
	4.8 BLENDING PREPARATION	27
	4.9 ENGINE TESTING AND ANALYSIS	28
	4.9.1 Engine Details	28
	4.9.2 Engine Test Rig Components	29
5	RESULTS, DISCUSSIONS, AND PERFORMANCE ANALYSIS	31
	5.1 PERFORMANCE PARAMETERS	31
	5.1.1 Brake Thermal Efficiency	31
	5.1.2 Specific Fuel Consumption	32
	5.1.3 Volumetric Efficiency	34
	5.1.4 Exhaust Gas Temperature	34
	5.2 EMISSION CHARACTERISTICS	35
	5.2.1 CO Emission	35
	5.2.2 Carbon dioxide Emission	36
	5.2.3 Hydrocarbon Emission	36
	5.2.4 Nitrogen Oxide Emission	37
	5.2.5 Smoke Opacity	38
6	SUMMARY AND CONCLUSION	39
	REFERENCES	40

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE No.
4.1	Titanium Oxide Nanomaterial	18
4.2	Aluminium Oxide Nanomaterial	19
4.3	Pithecellobium Dulce Seed Oil	19
4.4	Methodology	20
4.5	Transesterification of Biodiesel	21
4.6	XRD Graph	22
4.7	FT-IR Graph	23
4.8	SEM Images of Al ₂ O ₃	25
4.9	SE Values of the Nanoparticle	27
4.10	Sample Preparation	28
4.11	Engine Testing Setup	29
4.12	Gas Analyzer and Smoke Meter	30
5.1	Brake Thermal Efficiency	32
5.2	Specific Fuel Consumption	33
5.3	CO Emission	35
5.4	Carbon Dioxide Emission	36
5.5	Hydrocarbon Emission	37
5.6	Nitrogen Oxide Emission	37
5.7	Smoke Opacity	38

LIST OF TABLES

FIGURE NO.	TITLE	PAGE No.
1.1	Generation of Biofuel	2
1.2	Country and its potential feedstocks	10
4.1	Properties of Titanium Oxide	18
4.2	Properties of Aluminium Oxide	19
4.3	Properties of Pithecellobium Dulce Seed Oil	20
4.4	SEM Values	27
4.5	Engine Specifications	28

LIST OF ABBREVIATIONS

SFC	Specific Fuel Consumption
BTE	Brake Thermal Efficiency
CP	Cylinder Pressure
NHR	Net Heat Release Rate
CO ₂	Carbon Dioxide
O ₂	Oxygen
HC	Hydro Carbon
NO	Nitric Oxide
CO	Carbon Monoxide
EGT	Exhaust Gas Temperature
HRR	Heat Release Rate
TiO ₂	Titanium Oxide
Al ₂ O ₃	Aluminium Oxide
BP	Brake Power
VE	Volumetric Efficiency
NO _x	Nitrogen Oxide

CHAPTER 1

INTRODUCTION

INTRODUCTION TO BIODIESEL:

Biodiesel is an alternative fuel which can be used in the place of diesel. The preparation of biodiesel can be made using variety of oils, fats, and greases and it is very helpful to farmers and the reasons include It increases the market for vegetable oils and animal fats, it can allow farmers to grow the fuel and use them for their farm machinery, and it can increase the dependency of fuel on other countries.

Biodiesel is a renewable source of energy that can help in reducing NO_x emissions and minimize the “carbon content” in the atmosphere. It contributes less to global warming because the carbon in the fuel was removed from the air by the plant feedstock. Along with this biodiesel produces less air pollution like NO_x, Carbon mono oxide, carbon di oxide than diesel made from fossil fuels. A 1998 study by the USDA and US DOE found that using pure biodiesel in urban buses shows that there is a lot of decrease in the life cycle emissions of the total particulate matter around 32%, carbon monoxide around 35% and Sulphur oxides around 8% relative to petroleum diesel's life cycle this was concluded by Amin Talebian-Kiakalaieh, NorAishah Saidina Amin, Hossein Mazaheri.

BACKGROUND ON BIODIESEL:

Before proceeding to answer the research questions, it is important to establish some background about what biodiesel is, what it is made of, what its principal properties are, and the extent of its current usage in the state. This chapter will provide that foundation.

Definition:

In 1895, Rudolf Diesel developed a new engine with the intention that it could use variety of fuels, including vegetable oil. When he showcased it to the public at the 1900 Paris World's fair, he had the engine run on peanut oil. As the diesel engine became more widely adopted in subsequent years, however, petroleum-based diesel fuel proved to be less expensive and became the fuel of choice. Biodiesel's definition has been a work in progress. Since the early 1900s, biodiesel has been defined as an alternative

form of diesel fuel made from vegetable oils or animal fats and alcohol. The definition of biodiesel was neither legally definable nor defensible in the United States for about a century. This changed when biodiesel was registered with the U.S. Environmental Protection Agency (EPA) as a fuel and a fuel additive under section 211 (b) of the Clean Air Act. With help from the American Society of Testing & Materials (ASTM), subsequent legislation such as the Energy Policy Act (EPact) helped further define biodiesel.

In December 2001, the ASTM issued defined physical/chemical constraints for biodiesel and subsequently for mixtures of biodiesel with diesel fuel. An important distinction needs to be made between biodiesel and biodiesel blends. Biodiesel is commonly mixed with diesel No. 2 to form a biodiesel blend. As stated above, a mixture of biodiesel and diesel is not biodiesel, but is referred to as a biodiesel blend. Pure biodiesel, also known as neat biodiesel, is commonly noted as B100, indicating that the fuel has 100 percent biodiesel (noted by the 100) and 0 percent diesel. The most common biodiesel blend is B20, which contains 20 percent biodiesel and 80 percent diesel.

GENERATIONS OF BIODIESEL:

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.

Table1.1 Generations of Biofuel

Biofuel	Feedstock source	Advantages	disadvantages
<u>1st generation</u> * Wheat * Barley * Sugarcane * sugar beet * plant oil	Edible oil	simple conversation process	• Relative low oil yield • Biofuel debate • Causes deforestation and destroying ecosystem.
<u>2nd generation</u>	Non-	• Abundance availability	• Intractable

* Lignocellulosic biomass * Agricultural waste * Forest waste * Municipal solid waste	edible oil	number of non-edible crops worldwide. No debate between food vs fuel economy.	structure of the feedstock
<u>3rd generation</u> * Microalgae * Macroalgae * Microbes	Algal biomass	- High growth rate - Its cultivation reduces global warming.	It requires advance technology for biodiesel conversion

The First Generation of Biofuels:

Mohammad Rasul and NurMd Sayeed Hassan stated that these first generation of biofuels are produced from agricultural crops, which are a vital food source 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 of 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 within the farmers. Thus leading to usage of excess fertilizers and pesticides to increase the crop yield. This would change the chemical properties of the biodiesel to a certain extent. So this type of production of biodiesel was not entertained.

Sunflower oil

Using the American Society for Testing and Materials procedures, the synthesized sunflower-seed oil biodiesel was evaluated for its fuel characteristics, density, dynamic and kinematic viscosities, cloud point, flash point, acid number, and sulphur levels (ASTM). Because of the specified standard values for biodiesel (ASTM-D6751) and petroleum diesel, the findings are essentially the same (ASTM-D975). The fuel spray is less effectively atomized when its viscosity is high. At 40°C, the determined dynamic and

kinematic viscosities of sunflower-seed oil biodiesel were 5.321 cp and 4.719, respectively. These values fall within the ASTM D6751 and ASTM D975 tolerances for biodiesel and Petro-diesel respectively. The stretching of the CO molecule and the methoxycarbonyl give rise to two distinctively potent optical phenomena in esters. Sunflower biodiesel's methoxy group evolved from weak oil to a powerful band.

Soybean oil

The most extensively cultivated oilseed crop worldwide is the soybean. Additionally, in the US, it is the preferred source for the manufacturing of biodiesel. The iodine content of soybean oil and sunflower seed oil is similar (121-143). The soybean tree is between 0.5 and 1.2 meters tall. Because of their ability to fix nitrogen, soybeans may thrive in both temperate and tropical settings. In comparison to other crops, soybean has a lower oil production per hectare but as soybeans require less fertilizer, there is an efficient equilibrium between fossil fuels. The density, viscosity, and heating values of soybean oil are 916 kg/m³ (at 15 °C), 31.83 mm²/s (at 40 °C), and 39.6 MJ/kg, respectively. Linoleic acid (50-60%), monounsaturated fatty acids (20-30%), and hexadecenoic acid (6-10%) are all present in soybean oil.

Rapeseed oil

The primary ingredient in biodiesel is rapeseed, which has been upgraded twice. Rapeseed oil must conform to specific quality criteria specified in the standard for methyl esters as diesel engine fuels. Mechanical or chemical extraction is frequently used to get vegetable oils using various presses, and seed crushing is a traditional method of manufacturing oils. However, employing solvent extracts and chemical extraction may be a more contemporary method of getting vegetable oils. These techniques are frequently combined, for instance, after solvent extraction is applied to pressing. Some smaller facilities would prefer to merely use the pressing method rather than implementing the solvent extraction step.

Seed washing, preconditioning, flaking frying, screw pressing, solvent extraction, and desolventizing are the steps involved in the manufacturing of rapeseed oils. Degumming and distillation, aspiration, screen separation, and removal of small and large particles are all steps in the cleaning of rapeseed. The whole seeds are then preheated (to around 30-40°C) by indirect heating or direct heat before processing. The best method for producing

biodiesel is Transesterification since it is a well-known low-cost process that causes fewer issues for engines than other methods. Esterification of rapeseed oils, product separation, and method distillation follows after.

The majority of the process is based on rapeseed oil's Trans esterification interaction with an alcohol (methanol, ethanol), which results in the synthesis of alcohol esters and glycerol. At full load and 2000 rpm in a six-cylinder, four-stock, turbocharged direct injection diesel, the combustion properties of near rape seed oil biodiesel at 5%, 20%, and 75% of volume mixes are examined. The increased proportion of rapeseed oil biodiesel within the blends reduces the high cylinder pressure. The stoichiometry of the trans esterification of rape oil requires three molecules of methanol to react with one molecule of rapeseed oil, making the molar ratio of rape oil one of the most significant variables impacting the yields of methyl esters converted.

Seed of Cotton

Typically, China, Europe, and the United States are the cotton-producing regions. Cotton plants frequently grow to a height of 1.2 meters. The two cotton plant species that are used to make cotton seed oil are *Gossypium Hieracium* and *Gossypium hirsutum*. This oil contains several relatively non-glyceride substances, including sterols, carbohydrates, gossypol, resins, phospholipids, and linked pigments. In a 250 ml round flat bottom flask fitted with a reflux condenser submerged in a water bath to maintain the proper temperature, all trans esterification processes were conducted in duplicate runs. Physical characteristics include a density range of 917-933 kg/m³ (at 15 °C), a viscosity range of 34.79 mm²/s (at 40 °C), and a heating value of 39.5 MJ/Kg.

Palm oil

Palm biodiesel oil demand is rising quickly in Europe. The palm's height ranges from 10 to 15 meters. The advantage of palm oil over other oils is it is more affordable. The range of density, viscosity, and heating value is, respectively, 897 kg/m³ at 15 °C, 40.65 mm/s at 40 °C, and 39.867 MJ/Kg. palm oil comprises medium-chain saturated fatty acids in addition to monounsaturated fatty acids. The 25%, 50%, and 75% by volume blends of palm oil biodiesel on how they burn in DI diesel under various load situations and at constant speed were conducted using a high-speed direct injection car diesel engine with 2000 rpm and 100 Nm of torque. In comparison to diesel fuel, the majority

of study results show that the use of biodiesel fuel and altitude had an additive influence on the advancement in injection and combustion time.

The Second Generation of Biofuels:

Rahman, Md M., Mohammad Rasul, and Nur M.S. Hassan investigation 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 reduce the burden on the edible oil for preparation of biodiesel. So here no land is used solely for production of biodiesel, Biodiesel production from waste animal fat and improvement of its characteristics by synthesized nickel and magnesium additive. Energy Conversion Management 2009;50(3):498-502 its waste product is used for production of biodiesel. Non-edible food second 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.

Waste oil

Households, restaurants, and the food industry all produce waste vegetable oil. Oil is heated during the frying process in homes and restaurants, and several hazardous compounds are released like free radicals, which can cause the human body to produce cancerous cells. Unsaturated acid bonds get saturated because of the complicated reaction involving oil. Oil's quality is diminished when its saturated acid concentration is higher. The three variables are density (910.4), viscosity (39.07), and acid number (1.0037). By using resources of this kind that might need to be disposed of, waste oil generally is affordable and exerts additional ecological forces. Three categories of waste oil will be used to categorize it: waste oil from the food industry, waste oil from non-food industries, and waste oil from homes and restaurants. The oil that was once used to make edible products, such as rapeseed, coconut, soybean, and palm oils. Additional processing is required for these waste oils to remove residues and handle heated acid. Numerous co-products are created in the food factory as well, including biodiesel which is produced by

the pyrolysis of waste oil from non-food industries such as waste plastic oil and waste tire oil.

Depending on the free-fact acid, there are typically two forms of biodiesel production.

- Transesterification occurs at a transesterification rate of less than 2% in vegetable oil.
- Esterification procedure, more than 2% of vegetable oil with free carboxylic acid.

Animal fat

Today, animal by-products are used in biodiesel production. This is due to the low selling price. Companies developing these feedstocks for biodiesel production are increasingly replacing conventional motor fuels. Due to numerous animal scandals and infectious diseases, opportunities to use animal fat sources are not permitted. Beef tallow or mutton used cooking oil, lard, and omega residues are the parameters behind the development of 4th generation biodiesel feedstock. Fourth-generation biodiesel-supported synthetic biology. Less saturated fats from animal manure. High saturation levels exist in these feedstocks. Animal fat-based biodiesel is less suitable for use in cold climates around the world. An aqueous solution was used to clean the fat waste.

Jatropha

When compared to diesel fuel, the combustion parameters of jatropha biodiesel (JME100) in a diesel engine show that it releases heat at a slower pace and has a lower peak cylinder pressure. Diesel has a larger heat release from premixed combustion than jatropha biodiesel, which results in higher peak pressure and a higher rate of pressure increase in comparison. With 64 million hectares of land classified as uncultivated or waste, the jatropha tree has been identified as one of India's most significant sources of biodiesel. The material's heating value, density, and viscosity are 38.96 MJ/Kg, 916 Kg/m³ (at 15 °C), and 37.28 mm²/s (at 40 °C), respectively. Most of the components in jatropha are unsaturated.

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 waste water and absorbs oxygen from the water bodies. It also does not require any land for growing. So this feature has made algae very efficient to grow. These algae can be grown in pond

and waste water 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 a large scale.

Micro algae

Using a process known as Trans esterification, biodiesel is also made from algae oil, including both micro and macro algae. Algae culture is a form of aquaculture that involves the cultivation of algae to produce goods or food that is derived from algae. First, mechanical or chemical extraction methods are used to extract the algal oil. Both the open pond system and the closed system are employed for algae farming. The development of many species is through open pond systems here the lighting and water temperature are not controlled. The rising period is influenced by the environment. A photo bioreactor connected to a source of sunlight is part of the closed system. Photo bioreactor is an inside pond that contains a light-weight source, polyethylene bags, and plastic or glass tubes. Other growing systems that are enclosed in a greenhouse include closed systems or pond systems. Even if these systems are smaller for economic reasons, they nevertheless need to provide many benefits.

With the aid of those systems, algae will grow in unfavorable conditions, such as desert and semi-arid regions, and are frequently collected using flocculation or centrifugation processes. The esterification process is frequently catalyzed by enzymatic enzymes, both catalytic and non-catalytic. The quantity of free fatty acids (FFA) affects the type of catalyst used. Glycerol is a by-product of the process that is separated using mechanical or electrical stirring. Additionally, water is used to neutralize the pH value of the biodiesel as it is refined. After the refining process, a cleaner, alternative fuel with a diesel-like structure is produced that is less viscous, termed biodiesel. Algae produce a lot of CO₂ and have a strong photosynthetic rate, and proliferate quickly. This is frequently used for industrial and agricultural wastewater's nitrogen and phosphorus. As a result, both micro and macronutrients play a role in how accurately algae grow and accumulate lipids.

1.4 FEEDSTOCK SOURCES FOR BIODIESEL:

A variety of feedstock, including oil, algae, microbial oil, and animal fats, are frequently used to produce biodiesel. The four main categories of biodiesel sources include (a) edible

vegetable oils, such as wheat, rapeseed, mustard, milkweed seed, and linseed oil; corn, rice bran, palm, and coconut oil; and used frying oils, such as olive and rapeseed oils. (b) non-edible vegetable oil: *Jatropha curcas*, *Pistacia chinensis* Bunge seed, Sal oil, *Moringa oleifera*, *Madhuca indica* (mahua), *Salvadora oleoides* (Pilu), cotton seed oil, tobacco, *Calophyllum piperatum*, rocket gars, Terebinth, rubber seed oil, desert date, fish oil, jojoba, Neem oil, leather pre-f (c) Animal fats, including chicken fat, swine lard, bull tallow, and poultry fats. (d) Waste or recycled oil. Other feed stocks include bacteria, terpenes, latex, fungus, algae, and microalgae.

The expense of production is the main obstacle preventing more biodiesel from being produced. Another major issue is the availability of feedstock, which in turn is greatly influenced by several variables such as the geographical location where the fuel is generated and the type of oil resources that are available. Exactly 95% of the world's biodiesel production is from the first generation. More precisely, growing food crops to produce biofuels has also contributed to the significant, ongoing growth of biodiesel production and usage in the industry. The second generation of biodiesel is made from biomass or non-edible materials, such resources include non-edible energy crops as well as used cooking oil, grease, and fat. The latter feedstock, however, must be distinguished from waste-oriented ones in terms of feedstock sustainability.

To reduce the price of biodiesel used frying oil, soap stocks, yellow grease, and brown grease are viable feed stocks. Currently, discarded frying oils and fats gathered from sizable food processing and repair facilities are converted and mostly used in animal feeding. Soap stock is a by-product of the refining of vegetable oil that is significantly less expensive than edible-grade refined oils. Its market worth represents nearly a fifth of the cost of crude vegetable oil. Yellow grease is made from rendered animal fats and used frying oils that have less than 15% free fatty acids. Brown grease is referred to when the FFA level is above 15%. Due to their low price, these feed stocks are appealing.

Before choosing a feedstock, the availability and economic condition of the country is given special consideration. Soybean oil is used as a feedstock in Brazil and America, canola oil is used as a feedstock in Canada, coconut and palm oils are used as a feedstock in Indonesia and Malaysia, and rape oil is used as a feedstock in Italy, Germany, Finland, and the UK for biodiesel production. *Karanja* and *jatropha* have been

studied as potential future feed stocks for biodiesel in India. Previous biodiesel feedstock includes oils such as mustard oil, rapeseed oil, soybean oil, and sunflower seed oil. The use of edible oils as biodiesel feedstock has been a significant problem since it has an impact on the food chain. According to numerous studies, using non-edible oil as a feedstock for biodiesel has several advantages, including availability, biodegradability, low aromatic content, and little impact on nature. Animal oil, animal fats, oil, and microalgae are all acceptable sources of feedstock for the synthesis of biodiesel due to increasing demands.

The wide variation of choosing feed stocks for methyl ester production is a great advantage. According to the literature, only feedstock accession considers two-thirds of total biodiesel production costs. More than 350 oil-bearing crops are recognized universally as a biodiesel source which can be distributed into four major categories .such as (a) Edible vegetable oil: peanut oil, soybean oil, sunflower oil, Safflower, corn oil, Rice bran oil, palm oil, coconut oil, used fried oil, olive oil, rapeseed oil, mustard oil, milkweed seed oil, and linseed oil, wheat, (b) Non-edible vegetable oil: *Jatropha curcas*, *Pongamia glabra* (Karanja), *Madhuca indica* (Mahua), *Salvadora oleoides* (Pilu), cotton seed oil, Tobacco, *Calophyllum inophyllum*, *Eruca Sativa* Gars, terebinth, rubber seed oil, desert date, fish oil, Jojoba, Neem oil, leather pre-fleshings, apricot seed, *Pistacia Chinensis* Bunge Seed, Sal oil, *Moringa Oleifera* and *Croton megalocarpus*, (c) Waste or recycled oil and (d) Animal fats: chicken fat, pork lard, beef tallow, and poultry fats. Some other feedstocks are Algae, Bacteria, Micro-algae, Terpenes, Latexes, Fungi, etc.

Table 1.2 Country and its potential feed stocks

Country	Potential Feedstock
Argentina	Soybeans
Australia	Beauty Leaf, <i>Jatropacurcas</i> , <i>Pongamia</i>
Bangladesh	Rubber seed, <i>PongamiaPinnata</i>
Brazil	Soybeans/Palm oil/Castor/Cotton oil
Canada	Rapeseed/Animal fat/Soybeans/Yellow grease
China	<i>Jatropha</i> /Waste cooking oil/Rapeseed
Cuba	<i>Jatrophacurcas</i> , Moringa, Neem
France	Rapeseed/Sunflower
Germany	Rapeseed

Ghana	Palm
Greece	Cottonseed
India	Jatropha/Soybean/Sunflower/Rapeseed
Indonesia	Palm oil/Jatropha/Coconut
Iran	Palm, Jatropha, Castor, Algae
Ireland	Frying oil/Animal fats
Italy	Rapeseed/Sunflower
Japan	Waste cooking oil
Kenya	Castor Malaysia Palm Oil
Mexico	Animal fat/Waste oil
New Zealand	Waste cooking oil/Tallow
Norway	Animal fats
Pakistan	Jatropha curcas
Peru	Palm, Jatropha
Philippines	Coconut/Jatropha
Singapore	Palm oil
Spain	Linseed oil/Sunflower
Sweden	Rapeseed
Thailand	Palm/Jatropha/Coconut
Turkey	Sunflower, Rapeseed
UK	Rapeseed/Waste cooking oil
USA	Soybeans/Waste oil/Peanut
Zimbabwe	Jatropha

CHAPTER 2

LITERATURE SURVEY

Performance and emission analysis of a DI Diesel Engine using nano additives through Biodiesel blends with diesel, Ramalho et al. (2018): This study analyzed the performance and emissions of direct diesel engine using nano additives and diesel fuel, Khoo et al. (2023) The results showed that the direct diesel engine led to a significant reduction of NO_x and particulate matter while maintaining good engine performance.

Karthickeyan et,al. (2017) showed that Biodiesel fueling accelerated the SOC and reduced the pre-mixed heat emission at lower loads. Biodiesel fueling, on the other hand, had no effect on the HRR at moderate to high loads. Yamane et al. discovered that the bulk modulus difference between biodiesel and diesel is greater at lower temperatures and higher pressures.

PathikritBhowmick, A.K. et,al. (2017) Jain investigated on CalophyllumInophyllum oil starting from various biodiesel production techniques to its application in modern day diesel engines.

Rahman et,al. (2020) have demonstrated a two-stage transesterification for biodiesel production from raw CalophyllumInophyllum oil.

Nanthagopal et,al. (2021) have examined the significance of fuel injection pressures on single cylinder DI-CI engine working with CIB100 fuel. As per the results, the BTE of CIB100 was found to be directly proportional to the increment in fuel injection pressure concurrently escalating the overall NO_x emissions.

C. Syed Aalam et,al. (2018), C.G. Saravanan et,al. (2020) investigations have shown that using of biodiesel in direct injection diesel engines can reduce carbon oxides, carbon monoxide, hydrocarbon, and particulate matter emissions, but nitrogen oxide emission may increases.

Kao et.al. (2019) have studied the effects of aluminium nanofluid combustion in diesel fuel. Their experiments showed that the addition of aluminium nanoparticles to diesel provides a large contact surface area with water and high activity for the decomposition of hydrogen from water during the combustion process. During combustion, alumina serves as a catalyst and the aluminium nanoparticles are denuded and decomposed the water to yield the hydrogen.

Wahomeetal et.al. (2013) have discovered that biodiesel may be used with a minimal percentage of the blend in CI engines. They further claimed that as the percentage of biodiesel in the blend falls, the Brake Specific Fuel Consumption rises. Hariram and Shanil et, al. (2013) has prepared biodiesel through trans esterification process which used 2.5grams of sodium hydroxide as catalyst and 400 ml of Methanol as alcohol and maintained between 70°C and 100°C. While advancing the injection timing, the peak pressure and heat release rate were improved in this study.

Shah et.al. (2015) used rice bran oil biodiesel blends to evaluate an agricultural single cylinder water cooled CI engine. The 20% biodiesel blend operated effectively in the engine, with fewer CO, smoke, HC, and NOX emissions, according to the results. The results were not good with increasing biodiesel concentrations. Senthil Kumar and Manimaran et,al.(2014) have produced biodiesel from Pithecellobium dulce seed oil through pretreatment and then alkaline catalyzed trans esterification.

The biodiesel-to-diesel blends were tested in a CI engine, and the results showed that these blends could be one of the best biodiesels for CI engines. Lower blends improve thermal efficiency and significantly reduce fuel usage. The increase in biodiesel concentrations also lowered exhaust gas emissions.

Poves, M. D. Z., Marti, D. & Lo, M. Biodiesel from sunflower oil by using activated calcium oxide.73,317-326(2007) work showed that Biodiesel is a clean, renewable, liquid fuel that can be used in existing diesel engines without modification as pure or blend. Trans esterification (the primary process for biodiesel generation) via heterogeneous catalysis is using low cost waste feed stocks for catalysts synthesis is improves the economics of biodiesel production.

The current work presents an overview of the biodiesel production advancements using Titanium & Aluminium oxide-based catalysts (e.g., pure, supported, and mixed with metal oxides). The review discusses different factors involved in the synthesis of calcium oxide-based catalysts, and the effect of reaction parameters on the biodiesel yield of calcium oxide-based catalysis are studied. Further the common reactor designs used for the heterogeneous catalysis using Titanium & Aluminium oxide based catalysts are explained.

Wendi, Cuaca, V. & Taslim. Effect of Reaction Temperature and Catalyst Concentration for Producing Biodiesel from Waste Beef Tallow Using Heterogeneous Catalyst CaO from Waste Eggshell conducted detailed work on the catalytic activity mechanism, challenges and prospects of the application of calcium oxide-based catalysts in biodiesel generation are discussed. The study of calcium oxide-based catalyst should continue to be evaluated for the potential of their application in the commercial sector as they remain the pivotal goal of these studies.

SUMMARY OF LITERATURE SURVEY:

As to literature reviews were referred, and a valid course of action was determined and used in the current research work. The arrived conclusions are:

- Biodiesel from Pithecellobium Dulce Seed oil efficient in medium loads compared to low or high loads, so it is a good alternative fuel for CRDI engines.
- As we know that non-edible oils are suitable for the performance.
- Nano-sized particles can improve the combustion efficiency of biodiesel blends by increasing the surface area of the fuel droplets, leading to more complete combustion and reduced emissions.
- The use of nanoparticles can make the gasoline more stable and lubricious, which may improve engine performance and save the damage that occurs on engine parts.
- The use of nanoparticles in biodiesel blends is still a relatively new area of research, and there are many factors that can affect engine performance. The type and size of the nanoparticles, the concentration of the nanoparticles in the fuel, and the specific engine design and operating conditions can all have an

impact on engine performance.

- Nanoparticles in biodiesel mix with benefits in power output, emissions, and fuel efficiency. More study is necessary to fully understand the potential advantages and disadvantages of this technology and to optimize its application in diesel engines.
- Overall, while biodiesel blends with nanoparticles have shown promise for improving engine performance, including torque output, further research is needed to fully understand the effects of this technology on different types of engines and under different operating conditions.

CHAPTER 3

AIM AND SCOPE

AIM:

- Investigation is led on biodiesel because of its good balance of cost, less emissions, cold-weather performance and equipment compatibility.
- The oil is extracted from the seeds using a solvent extraction process or a cold press method.
- To prepare a blend of Pithecellobium Dulce Seed oil and diesel by the process of Trans esterification with 20% biodiesel and 80% diesel.
- To perform engine test on common rail direct injection (CRDI) by adding nanoparticles to blend.
- The extracted oil is pre-treated to remove impurities and moisture. This process involves heating the oil to a specific temperature and adding a catalyst to remove any remaining impurities.
- Optimizing the result and analysis of the test.

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. Also to provide direct injection for the most efficient way of functioning of the diesel engine.

CHAPTER 4

MATERIALS AND METHODS

The process is classified into four phases:

- Preparation of biodiesel.
- Blending of biodiesel to oil using nano additives to check the performance and emission.
- CaO nanoparticles are added to the B20 blend.
- Engine testing and analysis.

MATERIALS:

- Diesel.
- Pithecellobium Dulce Seed Oil.
- Al₂O₃ & TiO₂.
- CaO nanoparticles.

TITANIUM OXIDE:

Titanium dioxide (TiO₂), a naturally occurring titanium oxide, is one of the most widely used materials in the world. It is an odorless and tasteless white powder widely used in many industries due to its special properties. One of the most important properties of titanium dioxide is its ability to reflect and scatter light, making it such a versatile material as paints, coatings and plastics. It is also used as a UV blocker in sunscreen products and as a preservative in food and cosmetics. Titanium dioxide can be produced by a number of methods, including sulfate, chloride, and hydrothermal. The Kraft method is the most widely used method, where ilmenite (a titanium-containing mineral) reacts with sulfuric acid to produce titanium dioxide. In addition to its optical properties, titanium dioxide is also known for its chemical stability, making it resistant to corrosion and degradation. This property makes it useful in many industrial applications such as catalyst, ceramics and electronics manufacturing. 20 Overall, titanium dioxide is a versatile and versatile material with unique properties that allow it to be used in a variety of applications. However, security issues should be carefully considered and resolved while using it.



Fig 4.1: Titanium Oxide Nanomaterial

S.NO.	Properties	TiO ₂
1.	Density	4.23 g/cm ³
2.	Specific Heat	0.72 J/kg.K
3.	Energy Content	200-300 NJ/kg
4.	Loss Coefficient	0.0005-0.001
5.	Melting Point	2973 K
6.	Thermal Conductivity	1.7-2.7 W/m.K

Table 4.1: Properties of Titanium Oxide

ALUMINIUM OXIDE:

Aluminium Oxide (Al₂O₃), these are nanosized spherical particles from an alumina bulk. Alumina nanoparticles can be obtained by several methods including, pyrolysis, sputtering, sol gel and the most commonly preferred technique laser ablation. Laser ablation is convenient since it can be performed in the gas, liquid or even a vacuum environment. This is very advantageous since the collection of nanoparticles in a gaseous environment is harder and cumbersome than in a liquid. It is also easier to set specifications for the kind of nanoparticles you desire to obtain. Aluminum nanoparticles are usually found in two states, nearly spherical shaped individual particles or as oriented fibers. The properties of bulk alumina that allow it to be such a versatile element in the industry are different from those of its nanoparticles. Bulk aluminum's large diameter doesn't allow it to have a larger surface of interaction with its surroundings.



Fig 4.2: Aluminium Oxide Nanomaterial

S.No	Properties	Al ₂ O ₃
1.	Density	4-6.25 Mg/m ³
2.	Specific Heat	600J/kg.K
3.	Energy Content	250-370 NJ/kg
4.	Loss Coefficient	0.0004-0.002
5.	Melting Point	2815 K
6.	Thermal Conductivity	1.9-2.2 W/m.K

Table 4.2: Properties of Aluminium Oxide

PITHECELLOBIUM DULCE SEED OIL:

The Pithecellobium Dulce Seed Oil, is an essential oil derived from various types of conifers, most in the pine or cypress biotanical families. It is produced from the foliage, and sometimes the wood, roots, and stumps which have been left after cutting of trees for timber extraction.



Fig 4.3: Pithecellobium Dulce Seed Oil

S.No.	Properties	Results
1	Density	0.910g/CC
2	Kinematic Viscosity	1.922cSt
3	Moisture content	0.073%
4	Flash point by PMCC Method	94°C
5	Fire point by PMCC Method	109°C
6	Calorific Value	8213.611cal/g

Table 4.3: Properties of Pithecellobium Dulce Seed Oil

METHODOLOGY:

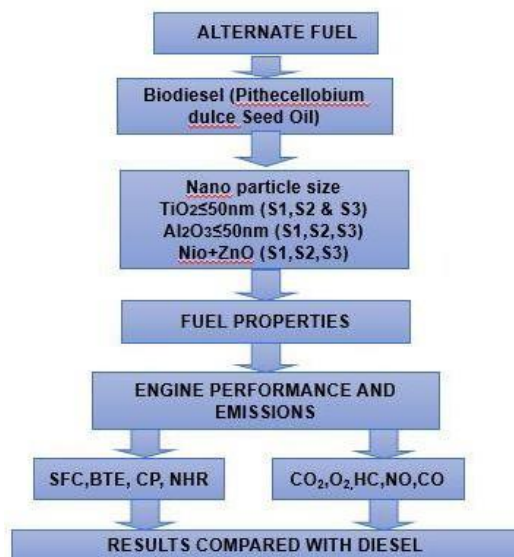


Fig 4.4: Methodology

TRANSESTERIFICATION OF PITHECELLOBIUM DULCE SEED BIODIESEL: The pithecellobium dulce seed oil is esterification using the primary catalyst. Since it has the free fatty acid, it is ready to produce the ester. In this stage the transesterification is carried out. This process is carried out for a particular period of time constantly. Later the esterification using the zirconium dioxide is carried out. The zirconium dioxide will not involve in any reactions with the pithecellobium dulce seed along with the diesel but it will make faster the process of the biodiesel preparation.



Fig 4.5: Transesterification of Biodiesel

PROPERTY TESTING AND ANALYSIS:

The main aim of property testing is to compare the physical and chemical properties of the fuel blend with the standard values. The prepared fuel blend is tested for their physical and chemical properties using various scientific instruments.

Characterization of Al₂O₃:

Al₂O₃ is the chemical formula for aluminum oxide, which is a compound composed of aluminum and oxygen atoms. It is commonly known as alumina and is a white, crystalline solid with a high melting point. Aluminum oxide is a hard, brittle material with a high melting point of 2050°C. It is a good electrical insulator and has a high thermal conductivity. It is also resistant to corrosion and wear. Aluminum oxide is a chemically stable compound, which means it is resistant to chemical reactions with most acids and bases. It can react with strong alkalis, such as sodium hydroxide, to form soluble aluminates. Al₂O₃ has a hexagonal crystal structure and is made up of layers of aluminum and oxygen atoms. It has a high degree of symmetry and is often used as a substrate for growing other materials due to its flat, uniform surface. Aluminum oxide has many applications, including as a raw material in the production of aluminum metal, as a refractory material for furnace linings and crucibles, and as a catalyst in chemical reactions. It is also used in the production of ceramic materials, such as cutting tools and dental implants, and as an abrasive in polishing.

and grinding applications. Overall, aluminum oxide is a versatile material with a wide range of applications due to its unique physical and chemical properties.

XRD Analysis:

X-ray diffraction (XRD) analysis is a powerful technique used to identify the crystal structure and phase composition of materials. Al_2O_3 (aluminum oxide) is a common ceramic material with a variety of applications in industry and research. XRD analysis of Al_2O_3 can provide important information about its crystal structure and purity. The XRD pattern of Al_2O_3 typically exhibits sharp peaks at characteristic angles, which correspond to the diffraction of X-rays by the crystal lattice of the material. The positions and intensities of these peaks can be used to determine the crystal structure and phase composition of the sample. The most common crystal structure of Al_2O_3 is corundum, which is a hexagonal close-packed structure with space group R-3c. Overall, XRD analysis of Al_2O_3 can provide valuable information about its crystal structure and phase composition, which is useful for understanding its properties and optimizing its performance in various applications.

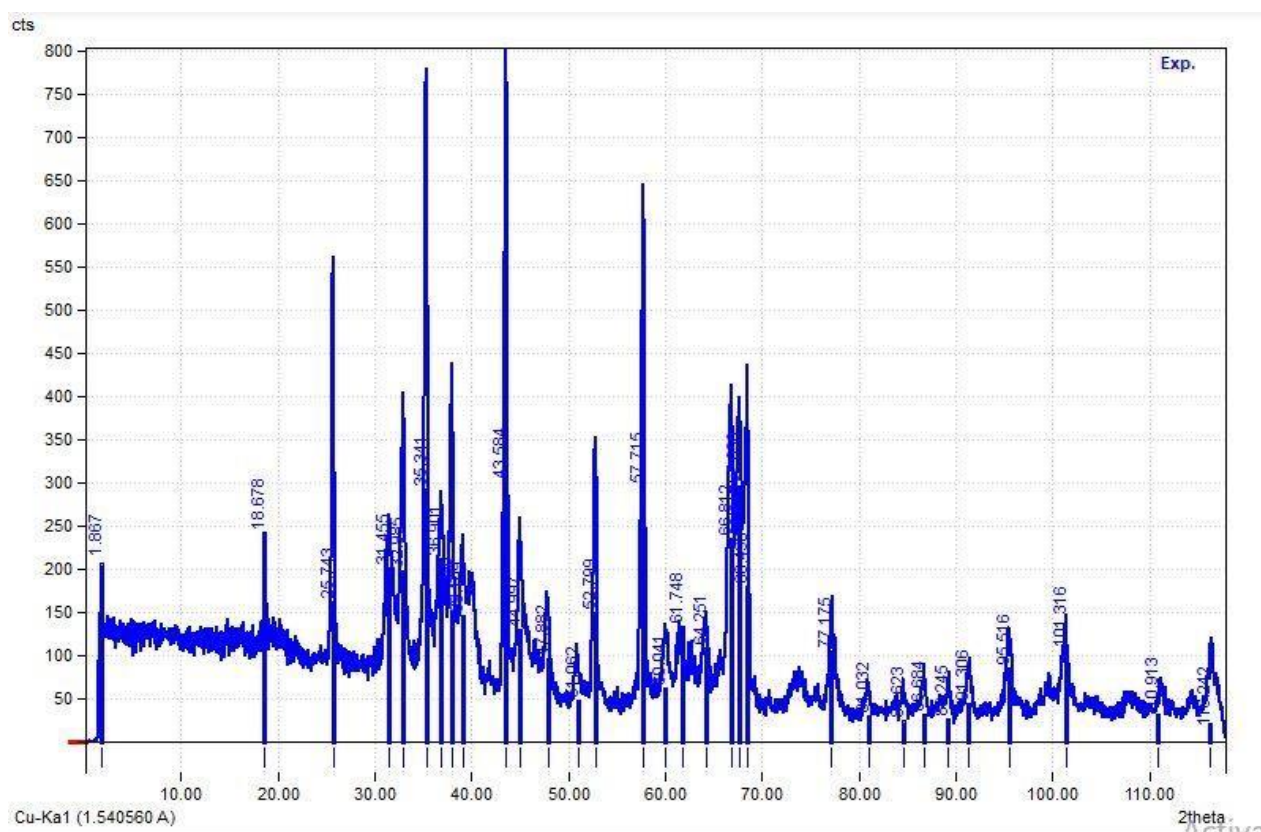


Fig 4.6: XRD Graph

FT-IR Analysis:

FT-IR (Fourier Transform Infrared Spectroscopy) is a common technique used to analyze the vibrational modes of molecules or solids. When applied to Al_2O_3 (aluminum oxide), it can provide information about the chemical bonds present in the material. In the FT-IR analysis of Al_2O_3 , the spectrum typically shows several peaks corresponding to different vibrational modes. The exact positions and intensities of these peaks depend on the crystalline phase and the level of impurities present in the sample. The FT-IR spectrum of Al_2O_3 can be used to identify the presence of impurities, such as Si-O bonds, which can appear as a shoulder on the Al-O stretching band. It can also be used to monitor changes in the surface chemistry of Al_2O_3 , for example, due to oxidation or reduction reactions. Overall, FT-IR analysis is a useful tool for characterizing the vibrational modes and chemical bonds in Al_2O_3 , and can provide important information for understanding its properties and behavior in various applications.

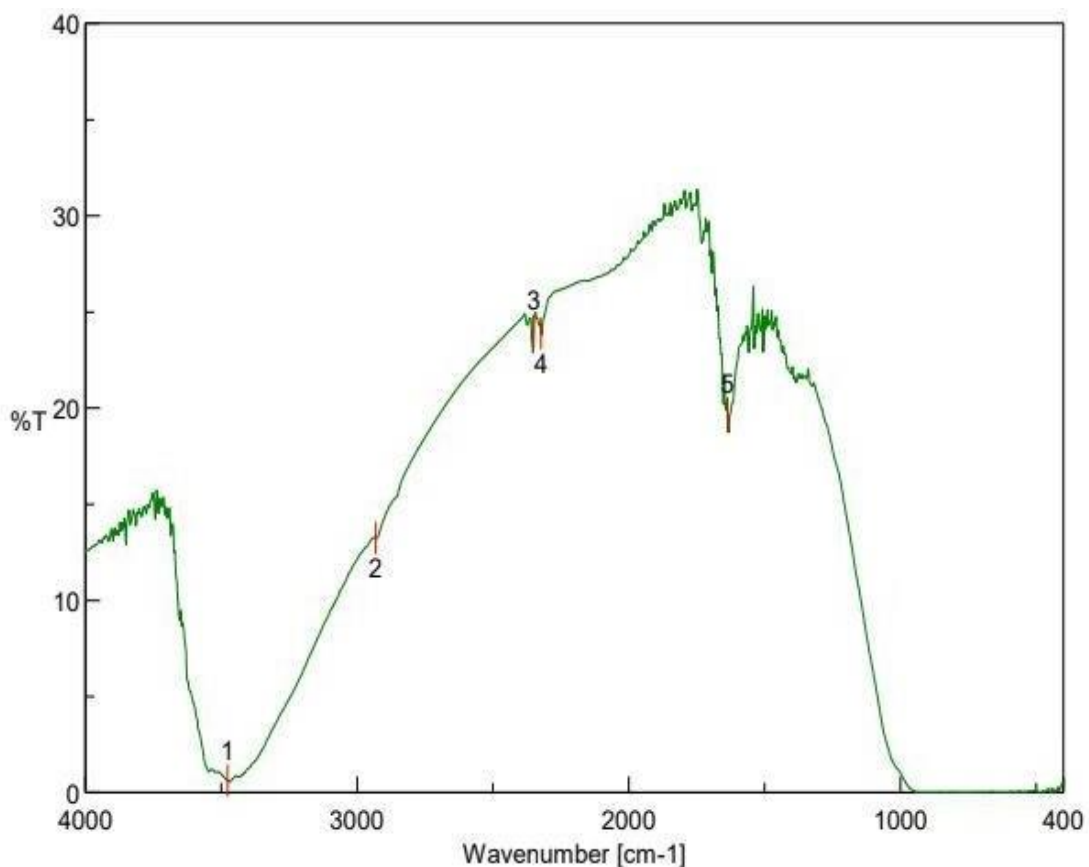
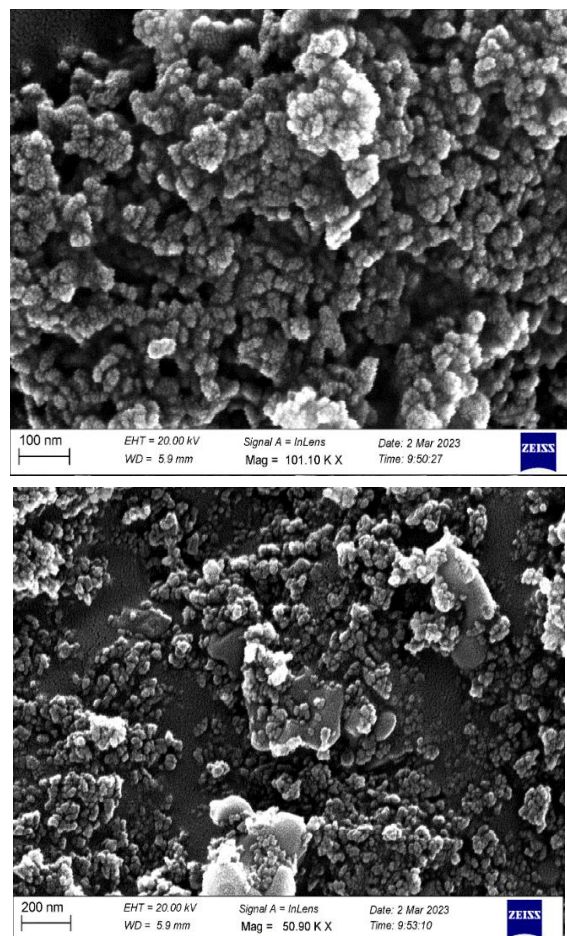


Fig 4.7: FT-IR Graph

FESEM (SEM-EDAX) Analysis:

FESEM stands for Field Emission Scanning Electron Microscopy and is a type of electron microscopy that produces high-resolution images of the surface of materials. Al_2O_3 , also known as alumina, is a ceramic material commonly used in a variety of industrial applications. To observe the surface of Al_2O_3 using FESEM, the material would need to be prepared by polishing and cleaning to remove any surface contaminants or debris. Once the Al_2O_3 sample is prepared, it can be placed in the FESEM chamber and bombarded with a focused beam of electrons. These electrons interact with the atoms on the surface of the material, causing them to emit secondary electrons, which are then collected by a detector to form an image. The resulting FESEM image of Al_2O_3 would reveal its surface features, such as grain boundaries, surface roughness, and any defects or impurities present on the surface. FESEM can also be used to determine the size, shape, and distribution of particles or pores on the surface of the material. Overall, FESEM is a powerful tool for characterizing the surface of Al_2O_3 and is widely used in materials science and engineering research.



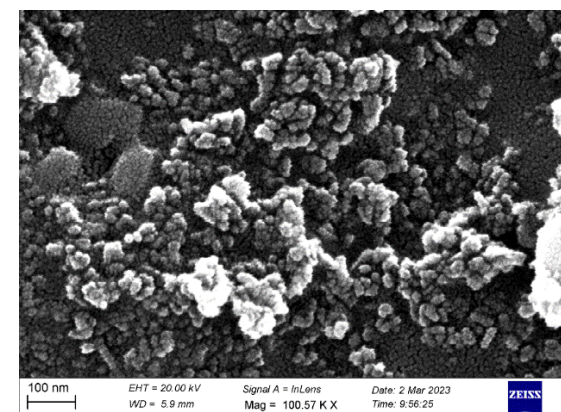
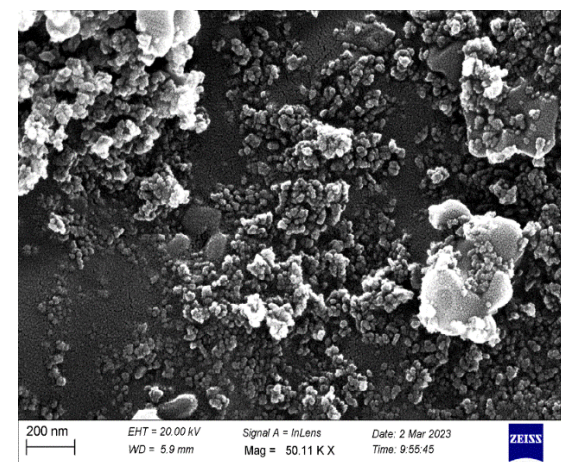
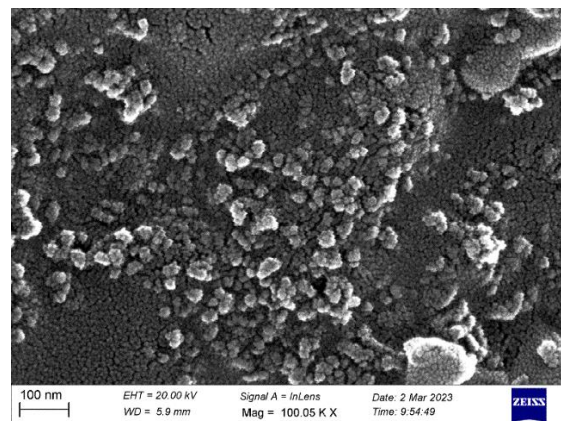
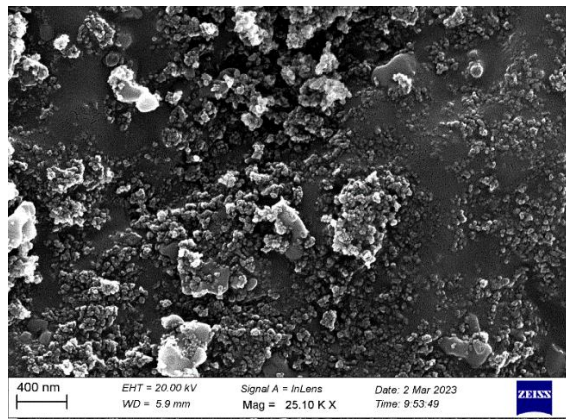
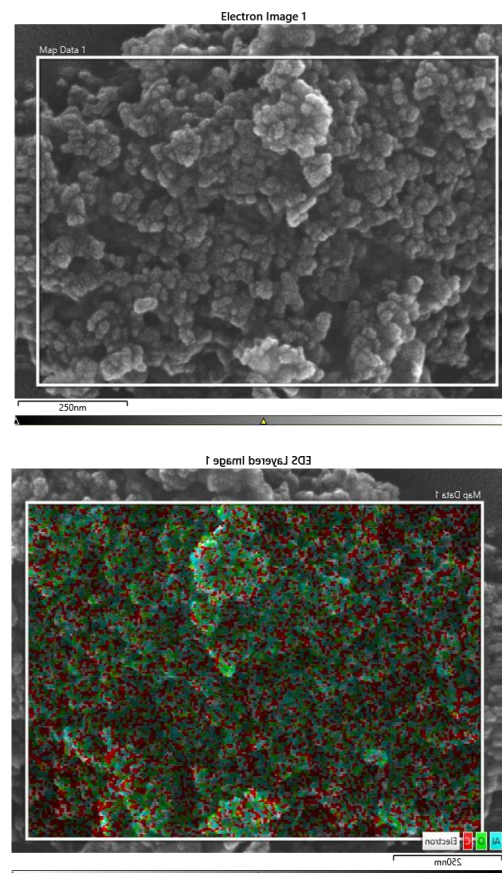
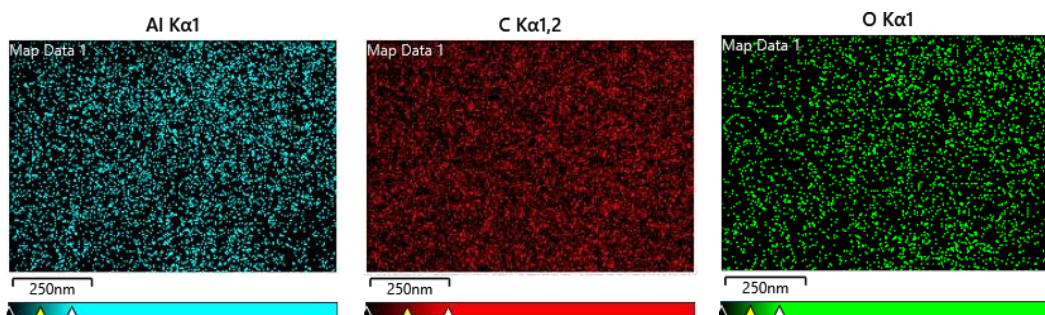


Fig 4.8: SEM Images of Al₂O₃

SEM-EDX stands for Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy and is a technique that combines the imaging capabilities of SEM with the elemental analysis capabilities of EDX. When used to analyze Al_2O_3 , SEM-EDX can provide information on the elemental composition and distribution of the material's surface. The technique works by scanning the surface of the Al_2O_3 sample with a focused beam of electrons, causing it to emit X-rays that are characteristic of the elements present on the surface. These X-rays are then collected and analyzed by an EDX detector, which can identify the elements present and their relative abundance. The resulting SEM-EDX spectrum provides a quantitative analysis of the elements present on the surface of the Al_2O_3 sample. In addition to elemental analysis, SEM-EDX can also be used to map the distribution of elements across the surface of the material, providing insights into the microstructure and chemical composition of the material. This information can be useful for understanding the properties and behavior of Al_2O_3 in various applications, such as in catalysis, coatings, and electronic devices.





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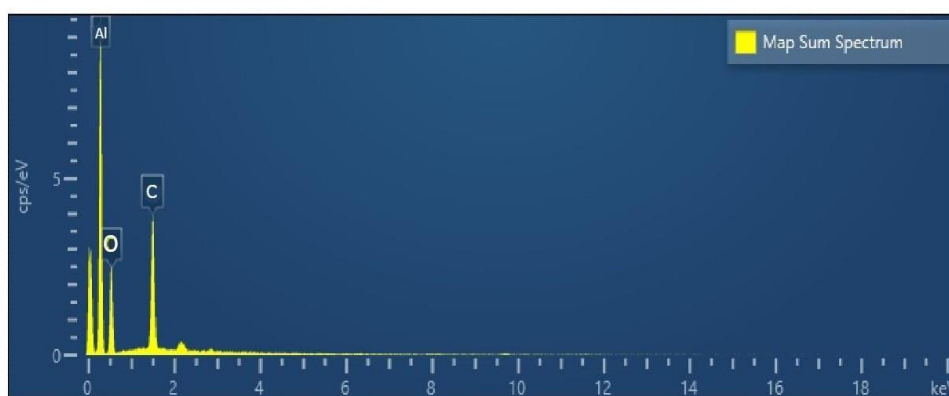


Fig 4.9: SEM Values of the Nanoparticle

Map Sum				
Element	Line Type	Weight %	Weight %	Atomic %
AL	K series	70.44	0.53	77.27
O	K series	24.75	0.53	20.39
C	K series	4.80	0.11	2.34
Total		100.00		100.00

Table 4.4: SEM Values

BLENDING PREPARATION:

Engine test using Biofuel with adding 100 ppm Al₂O₃ Nanoparticle

Sample 1 B10 (10% Biodiesel + 90% Diesel) with 100 ppm Al₂O₃ NP

Sample 2 B 20 (20% Biodiesel + 80% Diesel) with 100 ppm Al₂O₃ NP

Sample 3 B 30 (30% Biodiesel + 70% Diesel) with 100 ppm Al₂O₃ NP



Fig 4.10: Sample Preparation

ENGINE TESTING AND ANALYSIS:

An eddy current type dynamometer is used to load the single-cylinder, four stroke diesel engine for engine study. For measuring crank angle and combustion pressure, the necessary tools are provided.

Engine Details:

Engine Type	Vertical
No. of Cylinders	1
No. of Strokes	4
Power (BHP)	3.5 kW
Speed	1500 rpm
Bore	87.5 mm
Stroke	110mm
Cooling	Water Cooling
Dynamometer	Eddy Current Loading
Compression Ratio	12 to 18

Type of Ignition	Compression Ignition
Method of Start	Crankshaft

Table 4.5: Engine Specifications

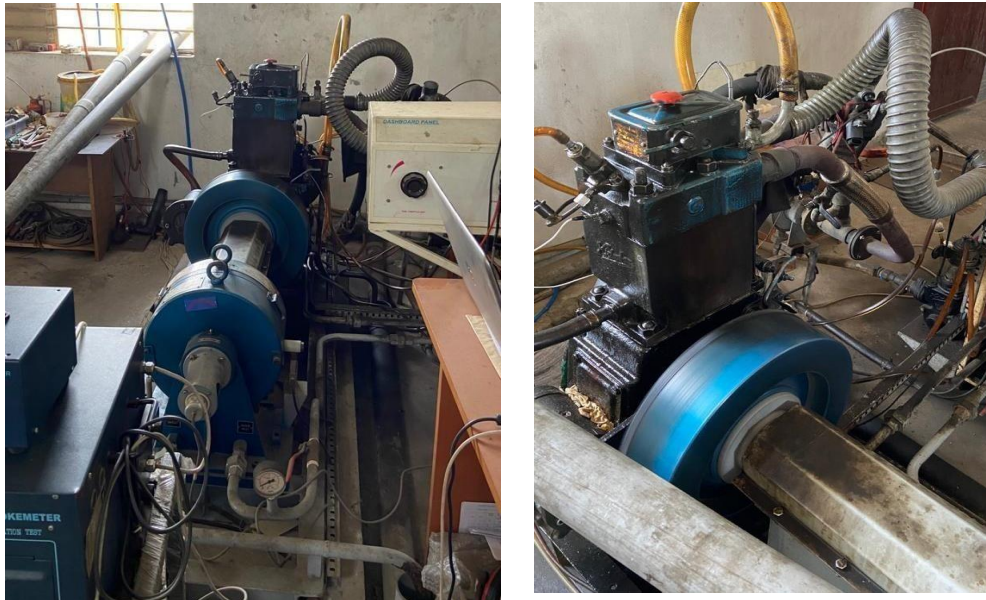


Fig 4.11: Engine Testing Setup

Engine Test Rig Components:

The Engine test rig is made up of a single-cylinder four-stroke diesel engine that is linked to the following components in the following order:

1. Eddy Current dynamometer (engine loading)
2. Panel box
3. AVL Smoke meter
4. Gas Analyzer
5. Fuel tank
6. Manometer
7. Fuel measuring unit

8. Digital speed indicator
9. Temperature Indicator



Fig 4.12: Gas Analyzer and Smoke Meter

Engine testing of biodiesel as a fuel requires the use of specialized instruments such as a smoke meter and gas analyzer to measure the exhaust emissions and ensure compliance with emissions regulations. A smoke meter is used to measure the opacity of the exhaust emissions from an engine, which indicates the level of particulate matter emissions. The higher the opacity, the higher the level of particulate matter emissions. On the other hand, a gas analyzer is used to measure the concentration of different gases in the engine exhaust, such as carbon monoxide, nitrogen oxides, and hydrocarbons. This instrument provides a comprehensive analysis of the engine exhaust, allowing for the measurement of different pollutants and their concentrations.

The smoke meter and gas analyzer work together to provide a comprehensive picture of the engine exhaust emissions, which is necessary for ensuring compliance with emissions regulations. The combustion of bio diesel as a fuel can produce higher levels of particulate matter and other pollutants than conventional diesel fuel. Therefore, careful monitoring of the engine emissions is necessary to ensure that the biodiesel fuel meets the required emission standards. These instruments are essential for evaluating the performance of biodiesel as a fuel and optimizing engine performance.

CHAPTER 5

RESULTS AND DISCUSSION

Engine testing is an important step in evaluating the performance of biodiesel as a fuel. After conducting engine tests, the results and discussion section should present the findings and discuss their implications. Graphs are used to illustrate and discuss the outcomes of the investigations. Brake thermal efficiency, specific fuel consumption, volumetric efficiency, and exhaust gas temperature are among the performance metrics. The combustion type of the engine is measured using cylinder pressure, Pressure volume graph and heat release rate. Carbon monoxide, unburned hydrocarbons, NOX, smoke opacity, and carbon dioxide are among the emission parameters.

PERFORMANCE PARAMETERS:

This section explains the performance aspects of blended fuel such as brake thermal efficiency, specific fuel consumption, volumetric efficiency, and exhaust gas temperature.

Brake Thermal Efficiency:

Brake thermal efficiency (BTE) is an essential performance indicator for evaluating the efficiency of internal combustion engines. It measures how efficiently the engine converts the fuel's chemical energy into useful mechanical work. It is calculated by dividing the engine's brake power output by the heat energy in the fuel consumed. A higher BTE means the engine can convert more of the fuel's energy into useful work, resulting in improved fuel economy and reduced emissions. In this regard, optimizing engine design and operation to improve BTE is a critical research area for developing more efficient and sustainable engines. Therefore, measuring and improving BTE is essential for enhancing the overall performance and environmental impact of engines.

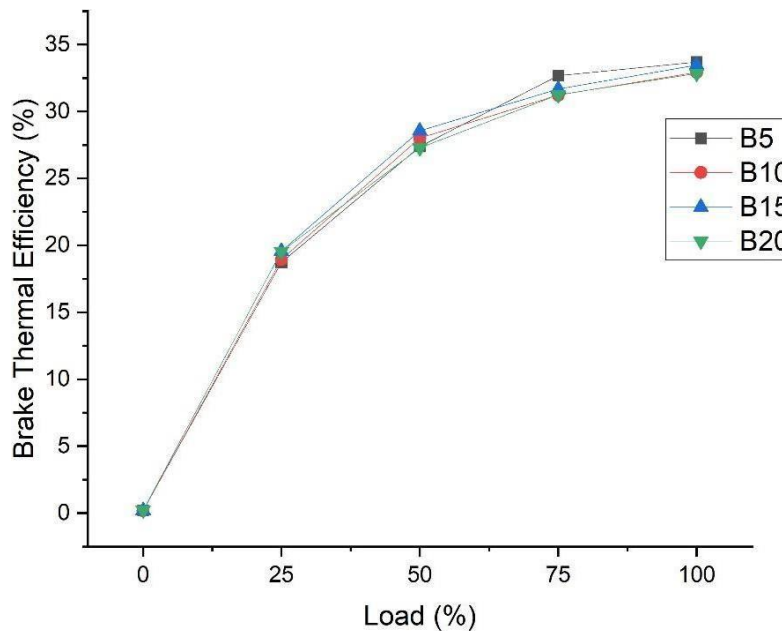


Fig 5.1: Brake Thermal Efficiency

An increase in BTE represents an improvement in engine efficiency, which translates into better fuel economy and reduced emissions. This makes increasing BTE a desirable outcome for engine manufacturers, researchers, and users alike.

Conversely, a decrease in BTE is an undesirable outcome as it indicates a reduction in engine efficiency. This can lead to reduced fuel economy, increased emissions, and lower power output. Several factors can cause a decrease in BTE, such as low-quality fuel, inefficient combustion, and mechanical losses in the engine. Therefore, improving BTE is a critical area of research to develop more efficient and sustainable engines.

Specific Fuel Consumption:

Specific fuel consumption (SFC) is a critical parameter for evaluating the fuel efficiency of internal combustion engines. SFC is defined as the amount of fuel consumed by the engine per unit time per unit power output. In other words, it represents the rate of fuel consumption of an engine for producing a given amount of power. SFC is an essential metric for engine design and optimization as it directly affects the engine's fuel economy

and operating cost. A reduction in SFC can lead to improved fuel economy, reduced emissions, and lower operational costs. Therefore, engine manufacturers and researchers are continually seeking new technologies and strategies to reduce SFC and improve engine efficiency.

In summary, specific fuel consumption is a key parameter for evaluating the fuel efficiency of internal combustion engines. It represents the rate of fuel consumption of an engine for producing a given amount of power and is a critical metric for engine design and optimization.

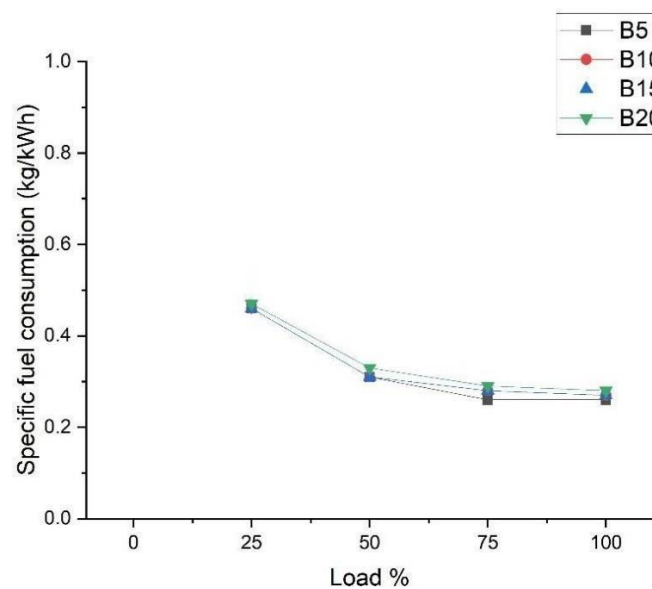


Fig 5.2: Specific Fuel Consumption

High SFC means that the engine consumes more fuel per unit time per unit power output. This indicates that the engine is less fuel-efficient and will consume more fuel to produce the same amount of power compared to an engine with a lower SFC. A high SFC leads to increased fuel costs, higher emissions, and reduced fuel economy. On the other hand, a low SFC indicates a more fuel-efficient engine that consumes less fuel to produce the same amount of power. This leads to lower fuel costs, reduced emissions, and improved fuel economy.

The importance of optimizing engine operating conditions and fuel properties to reduce SFC and improve engine efficiency. By developing new strategies and technologies to improve SFC, it is possible to achieve better fuel economy, reduced emissions, and improved engine performance.

Volumetric Efficiency:

Volumetric efficiency is a measure of an engine's ability to fill its combustion chambers with air and fuel mixture during the intake stroke. It is expressed as a percentage and is calculated by dividing the actual volume of air and fuel mixture entering the combustion chamber by the theoretical maximum volume that the engine can hold. Volumetric efficiency is an essential parameter for engine designers and tuners as it provides a measure of the engine's ability to produce power. It is often used in engine tuning to optimize the engine's air and fuel delivery system for maximum performance.

An engine with a high volumetric efficiency can fill its combustion chamber more effectively, resulting in better combustion and improved engine performance. This is because a high volumetric efficiency allows more air and fuel mixture to be supplied to the engine, which in turn produces more power.

Exhaust gas Temperature:

Exhaust gas temperature (EGT) refers to the temperature of the gases that are expelled from an internal combustion engine during the exhaust stroke. The EGT is a critical parameter in engine tuning and performance analysis, as it provides an indication of the engine's operating conditions and efficiency.

The temperature of the exhaust gas is affected by several factors, including the engine's fueling and ignition timing, engine load, and the quality of the fuel being used. When fuel is burned inside the engine cylinder, it produces heat, which raises the temperature of the exhaust gas. A higher engine load or more aggressive ignition timing can increase the temperature of the exhaust gas, while a richer fuel mixture can lower the EGT.

Monitoring the EGT is essential in high-performance engines, as excessively high exhaust gas temperatures can lead to engine damage, such as burned exhaust valves, cracked exhaust manifolds, and damaged turbochargers. A too-low EGT, on the other hand, can indicate incomplete combustion or insufficient fueling, which can result in a loss of engine power and increased fuel consumption.

EMISSION CHARACTERISTICS:

This section studies and discusses emission features such as CO emissions, CO₂ emissions, NO_x emissions, HC emissions, and smoke emissions findings by producing graphs for all emission levels at different loads.

CO Emission:

The CO (carbon monoxide) emission of bio-oil is affected by various parameters, including bio-oil content, engine type, operating circumstances, and combustion efficiency. Bio-oil is a complex combination of organic molecules whose composition changes based on the biomass source and processing method utilised. When compared to traditional fossil fuels, certain bio-oils have a greater oxygen content and lower heating values, which might result in incomplete combustion and higher CO emissions. Aside from fuel mix, engine type and operating circumstances can also have an impact on CO emissions. In a compression ignition engine, for example, fuel injection time and pressure can alter combustion efficiency and hence CO emissions. Bio-oil has been found in studies to release lower amounts of CO than standard diesel.

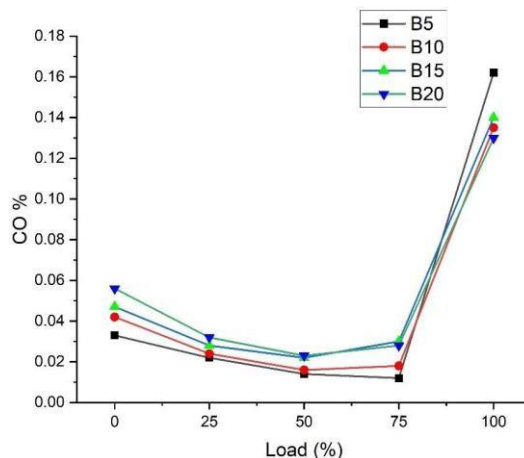


Fig 5.3: CO Emission

In summary, CO emissions from biofuels depend on many factors and will vary with fuel composition, engine type, operation and refinement. While some studies have reported that bio-oil blends reduce CO₂ emissions, more research is needed to understand the impact of bio-oils on CO₂ emissions and other pollutants.

Carbon dioxide Emission:

Biofuels generally contain more oxygen and lower energy than fossil fuels. This leads to incomplete combustion and higher CO₂ emissions. However, the carbon in the biofuel is considered part of the carbon cycle because the biomass feedstock used to produce the biofuel absorbs carbon dioxide from the atmosphere as it grows. Therefore, depending on the biomass feedstock and the process used, the carbon emissions of burning biofuels can be lower compared to fossil fuels.

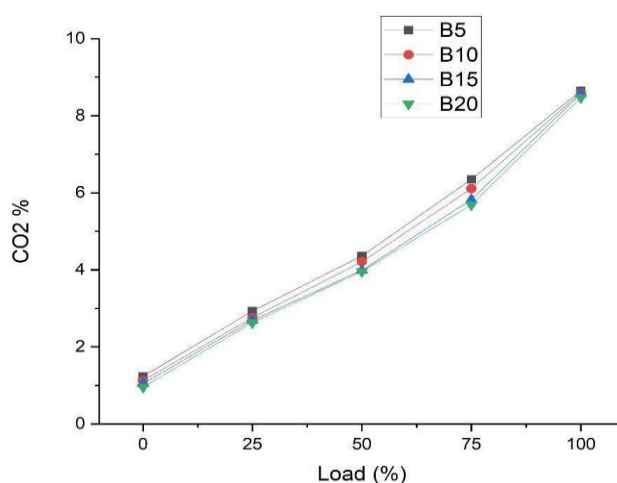


Fig 5.4: Carbon dioxide Emission

Hydrocarbon Emission:

Hydrocarbon emission is a sustainable and helpful alternative to fossil fuels. The burning of bio-diesel emits hydrocarbon pollutants that pollute the air and harm human health and the environment. As a result, it is critical to analyze bio-diesel hydrocarbon emissions and devise measures to minimize them.

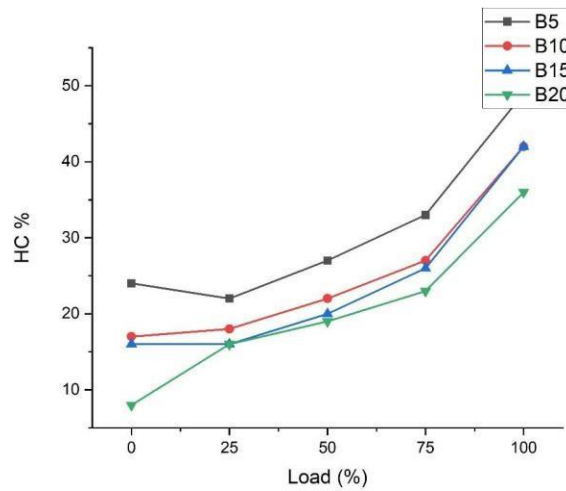


Fig 5.5: Hydrocarbon Emission

Nitrogen Oxide Emission:

Bio-oil synthesis produces nitrogen oxide (NO_x) emissions that cause air pollution and have adverse effects on human health and the environment. Therefore, it is important to study NO_x emissions from biofuels and develop strategies to reduce them.

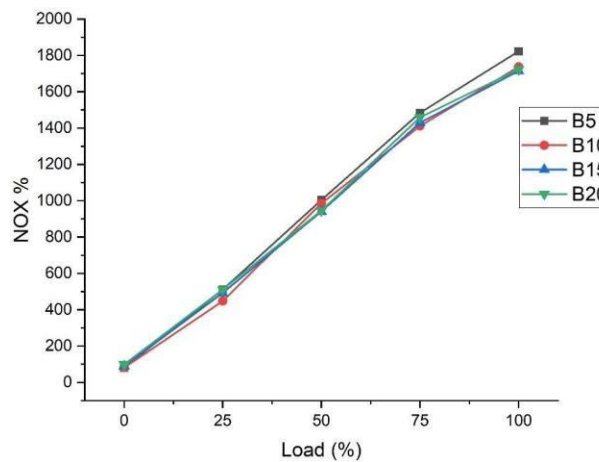


Fig 5.6: Nitrogen Oxide Emission

The NO_x emissions of bio-oils depend on several factors such as the type of engine, bio-oil content, and combustion conditions. While some studies suggest that the addition of bio-oil to conventional fuels can help to reduce NO_x emissions, others have shown an increase in NO_x emissions when bio-oil is used as a fuel. Further research is necessary

to fully understand the impact of bio-oils on NO_x emissions and to develop effective strategies to reduce them.

Smoke Opacity:

Bio-oil burning emits smoke, which degrades air quality and harms human health and the environment. As a result, it is critical to investigate the smoke opacities of bio-oil and devise measures to mitigate them.

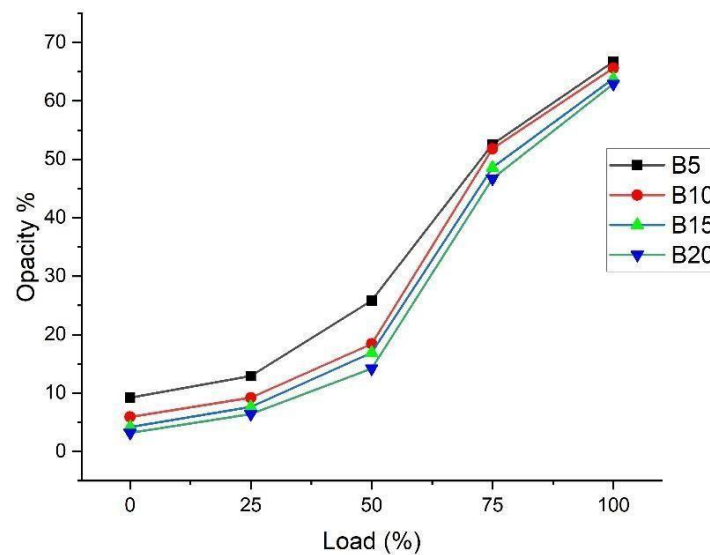


Fig 5.7: Smoke opacity

CHAPTER 6

SUMMARY AND CONCLUSIONS

- This study was an attempt to explore the possibilities of developing an alternative fuel source through mixed biodiesel pithecellobium dulce seed oil and diesel blends. Mixed biodiesel has been used as a flavouring agent but has never been researched in the field of biodiesel. It was also done in order to analyse the effect of Aluminium Oxide nano additive on the blends of mixed biodiesel and diesel.
- The emission results were positive with NO_x emissions at a depreciated value of 588ppm from the third sample S3 (**B30 + D70 + 100ppm Al₂O₃**) **at full load condition which is significantly lower than** neat/pure diesel which emits 588 ppm. The NO_x emissions were observed to be low under all the loads when compared to the other four blends prepared.
- This shows that the sample 3 diesel blend can be considered as an appropriate combination of biodiesel that can cut emissions of NO_x from a diesel engine. However, the CO and HC levels of the blends seemed to decrease drastically with respect to pure diesel. The readings obtained showed the emissions of S3 blend to be nearly twice the value of pure diesel under all load parameters.
- Hence, (sample 3) diesel blend can be considered useful in cutting off the NO_x emissions from the engine. Also, S1 diesel blend has shown appreciable results.
- The performance parameter, brake thermal efficiency was maximum and even higher than neat diesel from the usage of S3 diesel blend. The other samples readings observed were found to be close to the values of pure diesel under similar load condition than neat diesel.

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