

EXPERIMENTAL INVESTIGATION ON EMISSION PROPERTIES OF WATERMELON SEED BIODIESEL WITH TiO₂ NANO ADDITIVE

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in Mechanical Engineering

By

PURNAB BHOWMIK (Reg.No.37150144)

PROJUAL SAHA (Reg.No.37150142)



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 – 600119

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SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with "A" grade by NAAC
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119
www.sathyabama.ac.in



DEPARTMENT OF MECHANICAL ENGINEERING

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This is to certify that this Project Report is the Bonafide work of Purnab bhowmik (Reg. No. 37150144) and Projwal Saha (Reg. No. 37150142) who carried out the project entitled "**EXPERIMENTAL INVESTIGATION ON EMISSION PROPERTIES OF WATERMELON SEED BIODIESEL WITH TIO₂ NANO ADDITIVE**" under my supervision from September 2020 to April 2021.

Internal Guide

Mr V..SIRAM., M.E., Ph.D.,

Head of the Department

Dr. G. ARUNKUMAR, M.E., Ph.D.,

Submitted for Viva voice Examination held on _____

Internal Examiner

External Examiner

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ABSTRACT

In view of the current global situation, sustainable development and environmentally friendly living have taken centre stage. The performance of watermelon seeds in the development of biodiesel was investigated in this report. Furthermore, watermelon seeds are being tested to see whether they can be used as a biodiesel feedstock. Watermelon oil was trans esterified into biodiesel, and the properties of the biodiesel were measured, including flash point, fire point, viscosity, calorific value, and specific gravity. Various biodiesel blends, such as B10, B20, and B30, were prepared, and the properties of these blends were calculated. The above mixtures were checked in a diesel engine for efficiency and emissions, and the results were compared to Petro-diesel. The best blend for use as a working fuel was discovered in this research. According to the blends tested (B10, B20, and B30), B10 and B20 was the most successful at starting the computer. B10 and B20 had the most fuel and the least viscosity. Among other things, it had a low viscosity. The flashpoint and fire point of B10 are the lowest. B10 had all of the same features as other diesels.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Heat energy is transformed into mechanical energy using an engine. Internal combustion engines generate heat by burning fuel, which is then used to perform work. Gas combustion takes place in a combustion chamber, which is an essential component of an internal combustion engine. The high temperature and high-pressure gases created by combustion in an IC engine act as a direct force to some component of the engine. Fossil fuels such as natural gas or petroleum-based gasoline and diesel fuel are used in IC engines. Biodiesel and other renewable fuels are becoming more common for CI (compression ignition) engines. In 1892, Rudolf Diesel developed the diesel engine, which is a compression ignition engine. Because of the influence and benefits it had on social and economic life, the IC engine was created. An increase in the severity of environmental legislation together has to lead to the need for developing alternatives to conventional automotive fuels. Such as natural gas, hydrogen may provide sharp reductions of engine pollutants emission. Harmful pollutants like nitrogen oxide, carbon mono oxide, 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. 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 of fuels have been tested for combustion. Diesel is a form of liquid fuel obtained by 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 fuel. This biodiesel's properties are comparable to those of other biodiesels. Today's engines are designed to run on a range of fuels, including premium motor spirit (petrol), gasoline, or gas as their primary fuel. Of all of these engines, the diesel engine is the most suitable for running on biofuel. Furthermore, since biofuels are chemically very close to diesel fuel, no engine modifications are needed to run on biofuels. Diesel engine burns less fuel producing the same amount of work when compared to a petrol engine [3]. Biodiesel is a carbon-neutral source of fuel and is increasingly becoming popular. This is a liquid fuel that is created by chemically processing vegetable oil and altering its properties to make it perform like petroleum diesel. Biodiesel is very similar to Petro diesel, but they are not identical. However, the difference is remarkably small when we compare the procedure for making biodiesel and petrol diesel. Biodiesel is a carbon-neutral fuel that is becoming increasingly popular. This is a liquid fuel made by chemically refining vegetable oil and altering its properties to imitate petroleum diesel. While biodiesel and petroleum diesel are very

similar, they are not the same. When comparing the procedures for producing biodiesel and ethanol, however, the difference is surprisingly small. Transesterification, a chemical process that involves using methanol to modify the chemical properties of a vegetable oil, is used to manufacture biodiesel. Vegetable oil transesterification is a relatively simple process that produces a high conversion rate with glycerine as the only by product. The need to find and grow alternative energy sources is increasing in modern times, owing to a decline in the appeal of conventional energy sources such as fossil fuels, which have been around for a long time. Fossil fuels have been related to a number of health issues. The use of these energy sources over many years has resulted in global temperature levels also known as global warming. This is due to high levels of carbon that are released as by product and exhaust gases. This unfortunate situation gave rise to the search for alternative sources of fuels that are more environmentally friendly, the negative effect of petroleum-based fuels. Over the years there has been a steady increase in the amount of pollution produced by these fuels. Their methods of extraction have also led to serious cases of oil spills which tend to destroy the immediate or remote environment where such resources are found. This has also led to many political and socioeconomic problems over the world. Therefore, the search for other source of fuel began as early as 1800 during the early production of combustion engine. During this period, various oils were used to run engines until the mass production of various fuels overtook the older fuels. In Africa, especially Nigeria, there is a huge potential for the development of biofuels as an alternative energy source, this is due to the fact that there is wide variety of plants produced in the country that could be used as biofuel sources.

1.2 HISTORY OF DIESEL ENGINES:

Rudolf Diesel, a German engineer, came up with the idea for the engine that bears his name after searching for a way to boost the Otto engine's performance (the first four-stroke-cycle engine, built by the 19th-century German engineer Nikolaus Otto). Diesel discovered that if air could be heated to a temperature higher than the autoignition temperature, the electric ignition mechanism of a gasoline engine could be prevented.

After the experimental engine was killed by an explosion, Diesel changed to liquid petroleum to regulate the rate of coal injection. He began injecting fuel into the engine with compressed air. Rudolf Diesel struggled at first to compress the fuel to the pressures needed for spray dispersion, disintegration, and droplet formation.

As a result, the first diesel engine, which debuted in 1897, used compressed-air injection, in which the fuel was pumped into the cylinder using compressed air. Due to the low pressure at the nozzle, this approach had a problem with the air/fuel mixture penetration depth into the combustion chamber. As a result, more fuel is pumped (higher engine loads)

and engine speeds were not ideal for this method of mixture forming.

Direct injection (DI) and indirect injection (IDI) diesel engines are the two types OF diesel engines. The combustion chamber in the former is fully encircled by the cylinder head and piston surfaces, and it usually takes the shape of a hollow or bowl in the piston crown. In the latter, the combustion chamber is split into two parts: one is a cavity in the piston that is formed differently than in a direct injection engine, and the other is a pre-chamber that is connected to the cylinder by one or more passages. The diesel is injected into the pre-chamber.

1.2.1 Operation of diesel engine

In contrast to spark ignition (SI) engines, compression ignition (CI) engines have a higher thermal efficiency. Rudolf Diesel invented the CI engine in 1892. A diesel engine has one or two cylinders. The ignition of the air/fuel mixture propels the piston in each cylinder up and down. Because of this method of operation, it was given the name "reciprocating-piston engine." The connecting rod, also known as a conrod, converts the piston's linear reciprocating motion into crankshaft rotation. The crankshaft is kept spinning smoothly by a flywheel fixed to the end of the crankshaft, which eliminates the unevenness caused by intermittent fuel combustion in the individual cylinders. The speed at which the crankshaft rotates is referred to as engine speed. The diesel engine is a self-igniting engine that uses a mixture of fuel and air to start. The air needed for combustion is extremely compressed within the combustion chamber. This causes the diesel fuel to spontaneously combust when pumped into the cylinder, resulting in high temperatures. As a result, the heat produced by the diesel engine is used to liberate the chemical energy contained in the flange and transform into mechanical power. The engine operates on 4 stroke cycle. The conventional diesel operation is explained below

1.2.2 FOUR STROKE DIESEL ENGINE CYCLE OPERATION

In a Four stroke diesel engine the intake of air and the expulsion of burning gases after combustion are controlled by inlet and exhaust valves. They open and close the cylinders inlet and exhaust ports. Each inlet and exhaust ports can have one or two valves.

A] Induction stroke: From Top Dead Centre (TDC), the piston moves downward, increasing the cylinder's power. At the same time, the inlet valve (3) is opened, allowing air to enter the cylinder without being restricted by a throttle valve. When the piston reaches Bottom Dead Centre, the cylinder potential reaches its limit (BDC).

B] Compression Stroke: At this stage, both the inlet and exhaust valves have been closed. The piston rises and compresses the air in the cylinder to the degree calculated by the compression ratio of the engine (which can range from 6: 1 in large-scale engines to 24: 1 in automobile engines). During the process, the air is heated to temperatures of up to 900°C. The fuel injection mechanism injects high-pressure fuel into the moist, compressed air when the compression stroke is nearly complete (as much as 2,000 Bar in modern engines). As the piston reaches top dead centre, the cylinder power is at its lowest (compression volume, V_{ic}).

C] Ignition stroke: Once the ignition lag (a few degrees of crankshaft rotation) has passed, the ignition stroke begins. The finely atomized and readily combustible diesel fuel ignites and burns spontaneously due to the heat of the compressed air in the combustion chamber. The cylinder charge heats up even more as a result, and the cylinder pressure rises even higher. The amount of energy released during combustion is determined by the mass of fuel injected. The friction pushes the piston downward. The chemical energy released by combustion is used to transform the kinetic energy generated by combustion. The crankshaft drive transforms the kinetic energy of the piston into a turning force (torque) at the crankshaft.

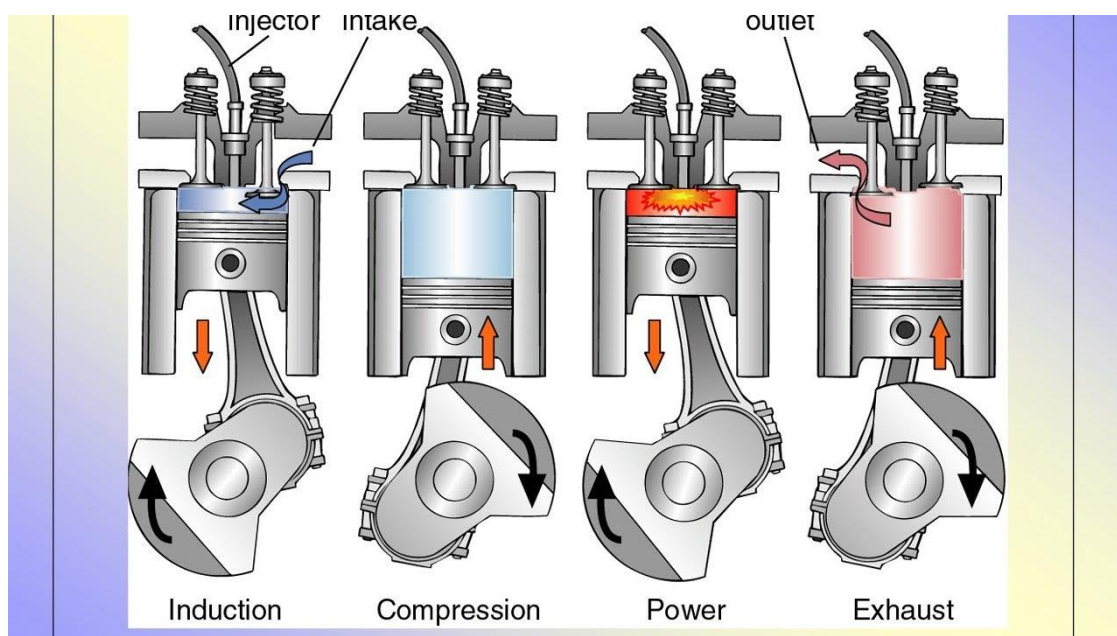


Fig 1.1 Operation of diesel engine

1.2.3 VALVE TIMING in Diesel engines:

Cams on the inlet and exhaust camshafts open and close the inlet and exhaust valves, respectively. On engines with a single camshaft, a rocker-arm mechanism transmits the camshaft's operation to the valves. The method of synchronising the opening and closing of valves with the movement of the crankshaft is known as valve synchronisation. As a consequence, valve timing is calculated as a percentage of the rotation of the crankshaft. The camshaft is driven from the crankshaft by a toothed belt or chain (the timing belt or timing chain), or sometimes by a series of gears. In a four-stroke engine, a complete working cycle takes two crankshaft revolutions. As a result, the camshaft rotates at half its normal rate. As a result, the transmission ratio between the crankshaft and the camshaft is 2:1. During the transition from exhaust to induction stroke, the inlet and exhaust valves are gradually opened for a period of time. This "valve overlap" helps to "clean out" any leftover exhaust and keeps the valves cool.

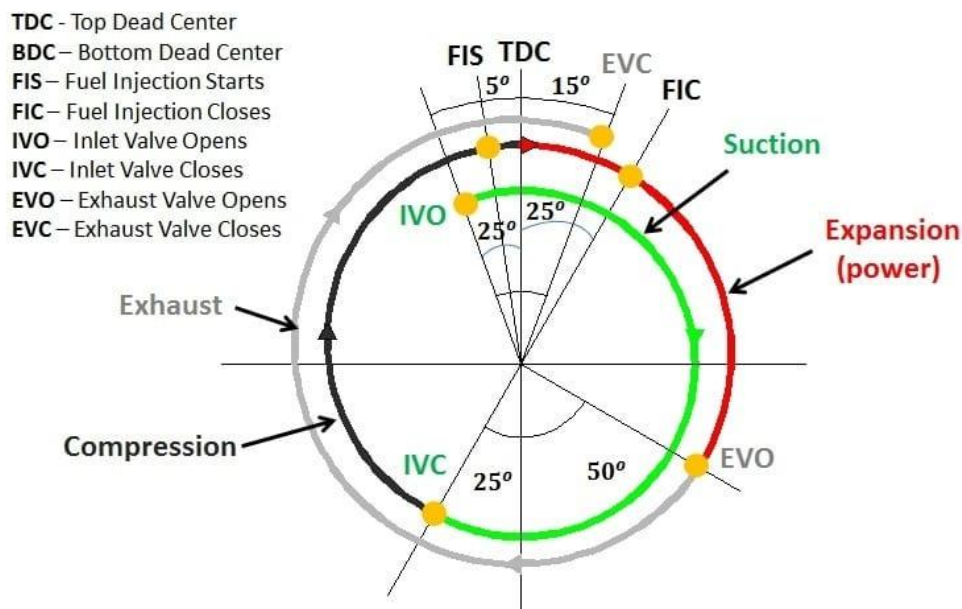


Fig 1.2 Valve timing diagram for diesel engine

1.3 EXTRACTION OF BIODIESEL

The mono alkyl esters of long chain fatty acid oils derived from sustainable lipoids such as vegetable and animal fats are known as biodiesel. B100 is a term that has been coined to describe 100 percent biodiesel. Biodiesel-to-petroleum-diesel blends are generally referred to as BYY, with YY denoting the proportion of biodiesel in the blend. B60, for example, contains 60% bio diesel and 40% petroleum distillate. Biodiesel can be made from four different process.

- 1) transesterification
- 2) Blending
- 3) Thermal cracking
- 4) Micro emulsion

Among these four processes transesterification is the best method to carry out the extraction of biodiesel.

1.3.1 TRANSESTERIFICATION PROCESS

Fig 1.2 shows the process of transesterification process. The triglycerides in the oil are manipulated to react with the alcohol. Methanol or ethanol are the alcohols of choice. The reaction occurs in the presence of a catalyst, which both facilitates and accelerates the process. Sodium hydroxide is the most common catalyst. Esters and glycerol are the end products. Since glycerol is a denser fluid, it sinks to the floor, while the biodiesel layer rises to the top. The whole procedure is reversible. It happens in three stages. In the first step, triglyceride is obtained. The production of monoglyceride from diglyceride occurs in the second stage. The formation of glycerine from monoglyceride is the final step. To improve the reaction and produce the exact product, a sufficient amount of alcohol is needed.

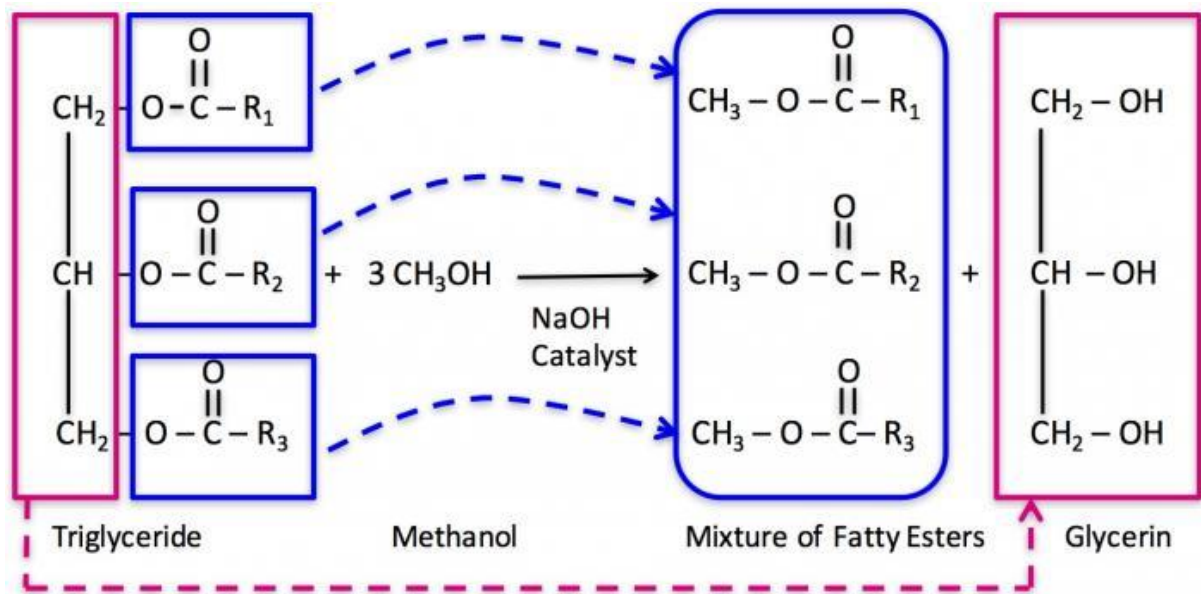


FIG 1.3 TRANSESTERIFICATION

1.3.2 NEED OF BIODIESEL

Since the engine output must be compared to traditional diesel, biodiesel is intended to be used exclusively in diesel engines. Bio diesel is mostly used to minimise emissions, but it also has a range of other benefits, including the fact that it is non-explosive, non-flammable, non-toxic, and biodegradable. It is so difficult for the poor countries to buy these conventional fuels so there is a need to use bio fuel which are economical in terms of cost and not causing harm to environment. Due to this reason biodiesel has to be used.

1.4 INFORMATION ABOUT BLEND

Bio diesel can be mixed in a variety of quantities and used in a variety of concentrations. B10 (up to 10% bio diesel) and B20 (up to 20 percent bio diesel) are the most widely used bio diesel blends; B100, which is the pure type of bio diesel used as a blend stock for lower blends but cannot be used for transportation, is seldom used. Blending diesel with biodiesel improves the biodiesel's properties and has a number of advantages. Bio diesel can be blended up to 30% in diesel fuel and used in C.I. engines without any modifications. The use of a B20 diesel blend in bunks. The diesel and bio ethanol blend can be used as alternative as a renewable fraction in automobiles which will grow attention in economic and environmental advantages. The stability will increase when biodiesel is added to the diesel fuel and while adding

the nano additive to the blend will loss lubricity of the fuel blend. Nano metal additives such as zinc oxide, aluminium oxide, iron oxide, and titanium oxide can be added to boost the fuel's performance, as well as improve combustion

characteristics, reduce ignition delays, increase density, and reduce emissions. Because of their performance characteristics such as volumetric efficiency, these blends are generally referred to as high performance blends.

1.4.1 EFFECT OF NANO ADDITIVE BLEND

Nano additives are nanoparticles that can improve the properties of biodiesel when blended with diesel. Through adding these Nano additives, the fuel enrichment method can be increased, and several studies have shown that these Nano additives are very useful in raising fuel properties, enhancing performance characteristics, and lowering exhaust emissions.

The surface area of nanoparticles is greater than that of bulk particles, and since their size is smaller, they can be easily blended into biodiesel and used in C.I. engines without modification. The reaction rates are increased by these nanoparticles. The following are some of the Nano additives that have been investigated as biodiesel additives like for ex- titanium dioxide, alumina oxide, Cerium oxide, magnesium oxide, cobalt oxide etc.

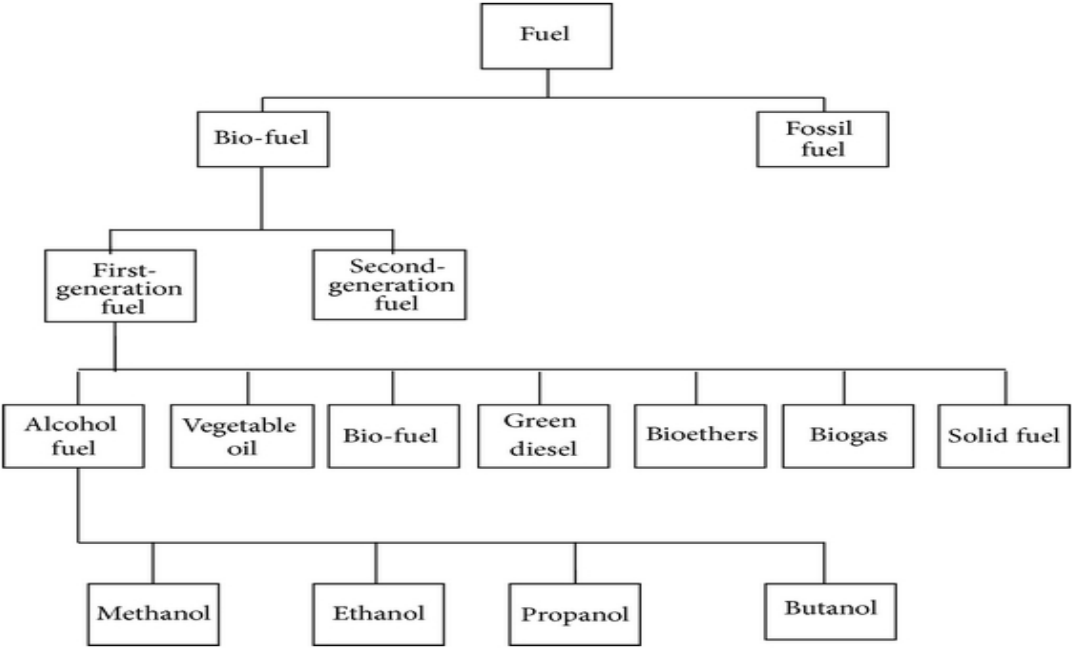


Fig 1.4 Titanium nano powder

1.5 PRESENT STUDY OF FUEL

The production of waste cooking oil is the all over the world these days, and if proper disposal procedures are not followed, the atmosphere will be contaminated. Since waste cooking oil is available from a variety of sources and is less costly than refined oils, it can be used as a low-cost feedstock for biodiesel production. We chose waste in this research. For the next process We have collected diesel, biodiesel and titanium dioxide nano additives. After That we prepared bio diesel and we blend with diesel and nano additive to Increase the engine performance and characteristics and to reduce the exhaust

Emission. Then we have blended the materials and prepare 6 blend three blend Without any adding nanomaterial next three by adding nano material.



CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION.

Many studies have been conducted on the development of biofuels, their properties, and their efficiency in diesel engines, as well as on the preparation of biodiesel from waste cooking oil, but only a few literature reviews have been conducted on the use of watermelon seed biodiesel blends in C.I. engines. about 190 research papers have been published in famous international journals and conferences on performance, combustion and emission characteristics of biodiesel-diesel blends. We referred many research papers and selected high performance fuel as our primary blend. Even though many researches have been done on this fuel but few researches only performed on addition of Titanium Nanoparticles to this high-performance fuel blend in order to increase the performance characteristics like volumetric efficiency, Specific fuel consumption, exhaust gas temperatures and to reduce the Carbon monoxide (CO), NO_x, HC and smoke exhaust emissions.

2.2 EFFECT OF BIODIESEL IN A C.I. ENGINE.

The alcohol derives biodiesel fuels like methyl ester and ethyl ester derived from waste cooking oil, according to Magniloquent, Jose M. Herreros (2008). On a volume basis, a 30 percent to 70% biodiesel blend with diesel was tested in a common rail injection compression ignition engine. The results of a marginal rise in fuel consumption, a smaller change in NO_x emissions, and excellent regulation of hydrocarbon emissions, smoke, and particle emissions are seen in this study. Biodiesel, according to Mangesh G Kulkarni and Ajay K Dalai (2006), is a non-toxic and biodegradable alternative fuel made from renewable sources. Waste cooking oil is the most cost-effective source of biodiesel among the many available options, as it costs far less than petroleum-based diesel fuel. Ashokan (2018) have performed the research on watermelon seed biodiesel blends with diesel fuel in Compression Ignition engine. The performance of engine and combustion results showed that at all engine loads while adding the biodiesel the ignition delay occurs due to biodiesel fuels having high cetane number. Also, addition of biodiesel results in less increase on Brake specific fuel consumption and reduces the Brake thermal efficiency but the HC and smoke emissions are reduced highly. Teja, N.B. and N. Lagomorpha, 2018 have performed the research on watermelon seed biodiesel blends with diesel fuel in Compression Ignition engine. The engine's output and combustion results revealed that when adding biodiesel, there is an ignition delay at all engine loads due to the high cetane amount of biodiesel fuels. Biodiesel also results in a lower increase in brake specific fuel consumption and a reduction in brake thermal efficiency, but it greatly decreases HC and smoke emissions.

2.3 EFFECTS OF HIGH-PERFORMANCE FUEL IN A C.I. ENGINE.

In a test, Li, Li, Wag, Jinxing, Wang, she, Xiao, Jianhua (2015) investigated the effects of adding Pentanol to diesel and biodiesel blends in various proportions in a single cylinder direct injection diesel engine and revealed the efficiency, combustion, and emission effects. For all loads tested, Pentanol blends have a higher indicated thermal efficiency than pure diesel for all tested loads from 0.5 to 1 mpa. Finally, it was discovered that a blend of 40% diesel, 30% biodiesel, and 30% pentanol provides superior combustion, pollution, and economic efficiency as compared to other fuels. Alpaslan Atmanli (2016) investigated and compared whether adding higher alcohols to diesel biodiesel blends produces positive economic and environmental outcomes due to the high cetane number and calorific value. The cloud point and cold filter plugging point increased, while density, heating value, kinetic viscosity, cetane number, and flash point slightly decreased. As compared to n-butanol and propanol, higher alcohols, such as 1-pentanol, have the most powerful results in reducing nitrogen oxides. Nadir yalmaz, et al. (2017) completed an experimental investigation on 1- Pentanol, a higher alcohol, in a C.I. engine when added to a diesel-biodiesel mix. According to the results of the engine test, adding 1-pentanol to a diesel-biodiesel blend improved brake specific fuel consumption and exhaust gas temperature. The results of engine testing also reveal that there is a decrease in brake thermal efficiency for the blended diesel fuels. . In contrast the diesel blends with 90% diesel and 10% 1-pentanol (D90 P10), 80% diesel and 20% 1- Pentanol (D80 P20) reduces the emission of oxides of nitrogen. In their paper, A. Prabhu and M Venkata Ramana (2018) reported that higher alcohols, such as Pentanol, have an enrichment in oxygen during combustion, which can act as a catalyst to the fuel for better combustion. Pentanol was blended with diesel blends in different amounts in their analysis, and the results showed that Pentanol can function as an oxidising catalyst, reducing carbon monoxide and other pollutants. and it also increases the brake thermal efficiency and the consumption of fuel is reduced. According to Prabhu Appavu, et al. (2019), quaternary blends (diesel-biodiesel-alcohol-vegetable oil) will substitute fossil fuels to a greater extent. The current research focuses on different proportions of Pentanol mixing with a diesel-biodiesel-vegetable oil blend, and the results show that increasing the addition amount of Pentanol reduces brake specific fuel and energy consumption. When it comes to pollution, hydrocarbons, carbon monoxide, and smoke are all decreasing, whereas nitrogen oxides are marginally increasing.

2.4 SUMMARY OF LITERATURE REVIEW

Many literatures have been carefully reviewed and analysed, and a series of findings has emerged from the literatures. Many methodological facts are used in the current research work, and the conclusions are drawn from them. The following are the findings and conclusions:

1. Without any modification in C.I engines the biodiesel obtained from the renewable sources like animal fats and plant seeds can act as an alternative fuel.
2. To replace the harmful fossil fuels the alternative biofuels should be produced from low-Cost feed stock and renewable sources like waste cooking oil, Jatropha seeds.
3. B20 blend which consists of 80% diesel and 20% biodiesel is best blend as it reduces the CO, HC, NOX emissions highly when compared to diesel fuels
4. The performance characteristics like brake thermal efficiency decrease and specific fuel consumption increases but the emission levels are controlled in a great level on addition of biodiesel to diesel fuels.
5. Nano additives can also act as an additive source to high performance fuel blend as they decrease the exhaust gas temperature
6. Addition of alumina Nano particles to the high-Performance fuel blend can increase the brake thermal efficiency and reduces the harmful exhaust gases.

After investigating many literatures, we get to know that so much of research have already done on the biodiesel blends. But there is very limited research done on the Nano particles addition to the high-performance fuel. So, this study is focusing on the performance, combustion, emission characteristics of the different blends with and without adding Titanium Nano additives.

CHAPTER 3

AIM AND SCOPE

3.1 AIM OF THE PROJECT

- 1) To prepare biodiesel from watermelon seed oil
- 2) To blend the watermelon seed oil with diesel and vegetable oil (High performance oil)
- 3) In the proportions specified, add the titanium Nano additives to the prepared blend.
- 4) After the preparation of blend test in the compression ignition engine and study the emission properties.

The aim of this study was to compare the efficiency, combustion, and emission characteristics of prepared blends with and without alumina Nano additives.

3.2 SCOPE OF THE PROJECT

Day by day the emission levels of the fossil fuels are increasing which causing the harmful effect to the atmosphere. To overcome this effect renewable and eco-friendly alternative source of biodiesel can be used. Watermelon seed oil is the best alternative for that. The blend of diesel and bio diesel will improve the engine characteristics and performance. The work provides how the engine works by the addition of titanium nano material with the blends

CHAPTER 4

MATERIALS AND METHODS

4.1 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 about the 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. Fourth step is to check the properties of the biodiesel and perform the engine testing. And the last step of the process is to perform the engine testing and analyze the performance, combustion and emission results.

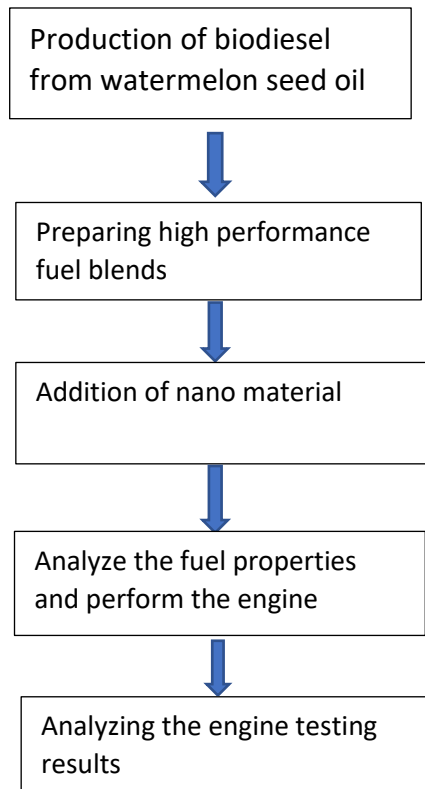


Fig 4.1: Flow Chart of Experimental Methodology.

4.2 MATERIALS REQUIRED

The materials required for the work are crude watermelon seed oil, methanol, sodium hydroxide and alumina nano additive.

4.3 THE BIODIESEL PRODUCTION FROM WATERMELON SEED OIL

The watermelon seed oil has been collected from the vendor which is near to The Satyabhama college. The detailed explanation of biodiesel preparation has been explained below in the section.

4.3.1 Mixing of Catalyst to Alcohol

The work uses sodium hydroxide pellets (Caustic soda) as a catalyst. The methanol must be mixed in these dry caustic pellets. Using a magnetic stirrer, approximately 5 grammes of NaOH pellets (0.858g of watermelon seed oil) are mixed with 170 ml of

methanol (molar ratio of 1:6 to watermelon seed oil) for about 30 minutes. The dry NaOH pellets were thoroughly combined with the wet NaOH pellets.



Fig 4.2: Mixing of Catalyst with alcohol

4.3.2 Transesterification Process

Transesterification is a crucial step in biodiesel production since it reduces the viscosity of the feedstock/vegetable oils to that of traditional fossil-based diesel oil. transesterification is a group of organic reactions in which the alkoxy moiety is exchanged, resulting in the transformation of one ester into another. It is a process In which the oil reacts with methanol in the presence of catalyst of sodium hydroxide Thus gives rise to the methyl ester and glycerine.



FIG 4.3: Transesterification process

This transesterification method is considered the most cost-effective because it produces nearly all forms of biodiesels while only requiring low pressures and temperatures. Using a magnetic stirrer, combine 1 litre of oil and the methanol and NaOH mixture for 3 hours at 300rpm in a conical flask. Temperatures of reaction should maintain about 60 degree throughout the reaction.

Sl.No	Parameters	Results
1	Free fatty acid	0.16 %
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	68 %

Table 4.1 transesterification properties

4.3.3 Separation process

The reacted mixture is poured into the two flasks with openings and allowed to settle for 15 minutes. Glycerine settles at the bottom of the conical separator flask due to gravity and higher density, while methyl ester or biodiesel remains at the top. Using the opening valve at the bottom, the glycerine can be quickly drained out. The two layers are easily distinguishable because they are identical.



FIG 4.4 Separation of glycerine from biodiesel

4.4 PROCESS OF PREPARING FUEL BLENDS

Pure diesel creates more emissions and is a non-renewable biodegradable fossil fuel. The transesterification process is used to prepare the substitute waste cooking oil, but biodiesel cannot be used directly in a compression ignition engine. As a result, biodiesel is blended with diesel and alcohol, as well as some vegetable oil, to achieve the best efficiency, combustion, and emissions according to different literature papers. So, the diesel was taken from the Bharat petroleum near Sholinganallur. Titanium dioxide nano material was brought from the chemical agencies and the watermelon seed oil was brought from the oil shop in Chennai. 500ml of three blends are prepared by adding diesel (80%), and 100 ml of watermelon seed oil biodiesel (20%). the components are measured by using measuring jar and using funnel the blends are prepared in a bottle. So totally 3 bottles of 750ml each Blends are prepared.

4.5 PROCESS OF ADDING TITANIUM DIOXIDE NANO ADDITIVES

For the better performance combustion and Emission, the alumina Nano additives are added to the prepared blends by referring many journals the proportions of alumina Nano particles to be added are taken as 50ppm and 100ppm. Alumina Nano particles were bought from the chemical agency in Chennai. The addition of these alumina Nano particles to the prepared blends are done in the Ultrasonicate.

4.6 PROPERTY TESTING

The physical and chemical properties of the fuel blends have to be test and the property tested results are compare with the American Society Testing and Materials (ASTM) standards. The various scientific instruments are used to test the properties of the fuel blends and the results are studied and compared with the ASTM standards. The various property testing like copper corrosion test, density measurement, viscosity measurement, calorific value measurement, moisture content, flash and fire point, cloud and pour point, are measured and compare with international standards.

4.6.1 Copper Corrosion Test

The copper corrosion test is a form of fuel property test that examines the copper corrosion behaviour of blends prepared for engine testing. The copper specimen is polished with silicon carbide abrasive papers and made to hang in the chamber during this process. Pour the blended fuel into the bottle and set aside for a few hours. After a few hours, the copper strip is cut, and the amount of copper corroded by our blends is measured. The obtained findings are compared to international norms.



Fig 4.5: Copper Corrosion Test Apparatus

4.6.2 Measurement of Viscosity

Viscosity is a property of fuel that can be measured with various viscometers. The viscosity of the prepared blends is measured using a Canon-Fenske Viscometer. The ready-to-test blend is poured into the beaker, which is then placed in the tube's thinner arm. The blended fuel will travel upwards due to the suction force generated.

The setup should keep at the constant temperature bath and leave the setup for about 30 minutes. Applying suction force should be stop and let the fuel blend to drop from the mark at the top to the mark at bottom and the time taken to reach from top mark to bottom mark is noted for all three blends prepared. The result obtained can be compared with the international standards.

4.6.3 Measurement of Density

The density of the fuel is a very important property, and it can be calculated using a device called a hydrometer. The hydrometer is a device that is used to calculate the relative density of liquids. Hydrometers are usually made of glass, with a cylindrical stem and a bulb that is weighted with a hard material to keep it afloat. The biodiesel's density is determined by pouring the 250 ml of biodiesel into the beaker. Stabilization happens in the beaker, where the fuel blend becomes more stable, and the hydrometer shows the real gravity of the fuel blend. The density obtained should be compared to international norms.

4.6.4 Measurement of Moisture Content

Moisture content monitoring is part of the fuel blend property testing. By putting a fuel blend sample of about 10 grammes of fuel in a metal container and measuring the weight of the container, the amount of moisture present in the fuel blend can be determined. Heat the sample and the jar in the oven at 1100 degrees Celsius. Then after heating the weight of the metal container is tested and the difference between the weights of the metal container before and after heating is noted down as the moisture content present in the fuel blend.

4.6.5 Measurement of Calorific Value

The Bomb Calorimeter is mainly used to evaluate the calorific value of liquid fuel samples at a fixed volume. Typically, this system burns a fuel sample and transforms the heat into a known mass of water. Calorific value is the amount of heat released in calories when a fuel is heated with oxygen at a specific temperature. The bomb calorimeter's vessel is equipped with a tight screw cap. The sample is mounted in a platinum cap with two electrodes attached to it, and oxygen is allowed to enter the vessel. Dip the vessel into the water bath, which also includes the stirrer and thermometer. For all prepared blends, the initial and final temperatures after combustion are registered, and the calorific value is determined.



Fig 4.6: Bomb calorimeter

4.6.6 Measurement of Cloud and Pour Point

Cloud point refers to the temperature at which the wax in the fuel takes on a cloudy appearance. The point at which the fuel becomes almost semi-solid and loses its flow parameters is known as the pour point. The fuel mixture is placed in a test tube, and the sample is placed in a system that is used to verify these properties and set the temperature accordingly and note the temperature. The Cloud point is the temperature at which the fuel takes on a cloudy appearance, and the Pour point is the temperature at which the fuel blend samples lose their fluidity.



Fig 4.7: Cloud and Pour point machine.

4.6.7 Measurement of Flash and Fire point

The lowest temperature at which the fuel vapours begin to burn after the ignition source has been removed is known as the fire stage. The lowest temperature at which a liquid can give off enough vapour to create an ignitable mixture is called the flash point. The sample is placed in the brass cup, which is then sealed with a lid. The sample is thoroughly heated and stirred until the ignition source is introduced and steering is also simultaneously done to the fuel blend. The Flash point is the temperature at which the fuel ignites by spreading the fuel vapour inside the brass cup. Notice the temperature at which the fuel ignites for up to 5 seconds. This is the Fire stage.



Fig 4.8: Flash and fire point apparatus.

S.No	Parameters	Results
1	Acid Value	0.33 NaOH/gram of oil
2	Density	0.858 g/cc
3	Kinematic Viscosity @ 40°C	1.16 cSt
4	Flash point by PMCC method	178 °C
5	Fire point by PMCC method	186 °C
6	Copper Strip corrosion @ 60°C	1 a
7	Cloud point	1 °C

8	Pour point	-7 °C
9	Moisture content	0.01%
10	Calorific value	7492.08 Cal/g

Table 4.2 Properties of watermelon seed oil biodiesel

4.7 ENGINE TESTING AND ANALYSIS

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Electric start Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements.



Fig 4.9 Testing Engine

4.7.1 Engine Details

The engine specification where various test has been performed and shown in the table 4.3

Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100°C,3 Nos; Thermocouple, Range 0-1200 °C,
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

Table 4.3 Engine Specification

4.7.2 TEST RIG COMPONENTS

The test rig consists of a single-cylinder four-stroke diesel engine which is connected to the following components in the order specified below

- 1) Hydraulic dynamometer (engine loading)
- 2) Panel box
- 3) Airbox
- 4) Fuel tank
- 5) Manometer
- 6) Fuel measuring unit
- 7) Digital speed indicator
- 8) Temperature indicator

The above-mentioned components are the major parts that are necessary for the working of the test rig. The eight major components present serves various use in the different operations conducted in the test rig. Proper maintenance of these components in this engine test setup is necessary for the efficient working of the system



Fig 4.10 Smoke and Gas Analyzer

Fig 4.9 shows a gas analyser and a smoke meter. The diesel exhaust smoke meters are also known as opacity meters which identify and measure the amount of light blocked in a sample of smoke given out by diesel engines. The smoke meter displays the smoke density giving the rate of the efficiency of the combustion. The smoke meter consists of an optical unit mounted inside a measuring head which also has a separate electrical control unit. The gas analyser is of the principle that the absorption of light by the gas under test. The analyser only needs to shine a beam of light via the unheated chamber then it is measured to understand how much, the specific wavelength was observed by the sample. The analyser consists of an optical filter that cancels out all light leaving the wavelength that the selected gas molecule can observe. Other gas molecules will not absorb light at this particular wavelength, and they don't even affect the amount of light reaching the detector

4.7.3 Combustion Parameters

The combustion parameters of the engine are shown below in the table 4.4

Specific Gas Const (kJ/kg.)	1.00
Air density (kg/m ³)	1.17
Adiabatic Index	1.41
Polytrophic Index	1.06
Nanocycles	10
Cylinder pressure reference	6
Smoothing	2
TDC reference	2

Table 4.4 Combustion Parameters

CHAPTER 5

RESULTS AND DISCUSSION

According to the objectives and methodology discussed, experimental investigations on the engine operated by a high-performance blend of diesel along with an B20 blend were conducted and the results are presented in this chapter. For comparison purposes, a normal engine was also tested for the same conditions (using the same blend of diesel). The results obtained from the experiments are presented and discussed through graphs. The performance parameters include brake thermal efficiency, specific fuel consumption, volumetric efficiency, and exhaust gas temperature. Cylinder pressure and heat release rate are used to measure the combustion nature of the engine. The emission parameters include carbon monoxide, unburnt Hydrocarbons, NO_x , and Smoke opacity and carbon dioxide

5.1 PERFORMANCE CHARACTERISTICS

Brake thermal efficiency, specific fuel consumption, and volumetric efficiency and exhaust gas temperature which are all the performance characteristics of the blended fuel are explained in this section

5.1.1 Brake Thermal Efficiency

Brake thermal efficiency (BTE) is utilized for evaluating the engines capability of converting the heat energy produced from the diesel fuel during combustion into mechanical energy. Brake thermal efficiency values are largely affected by fuel properties like heating value and density.

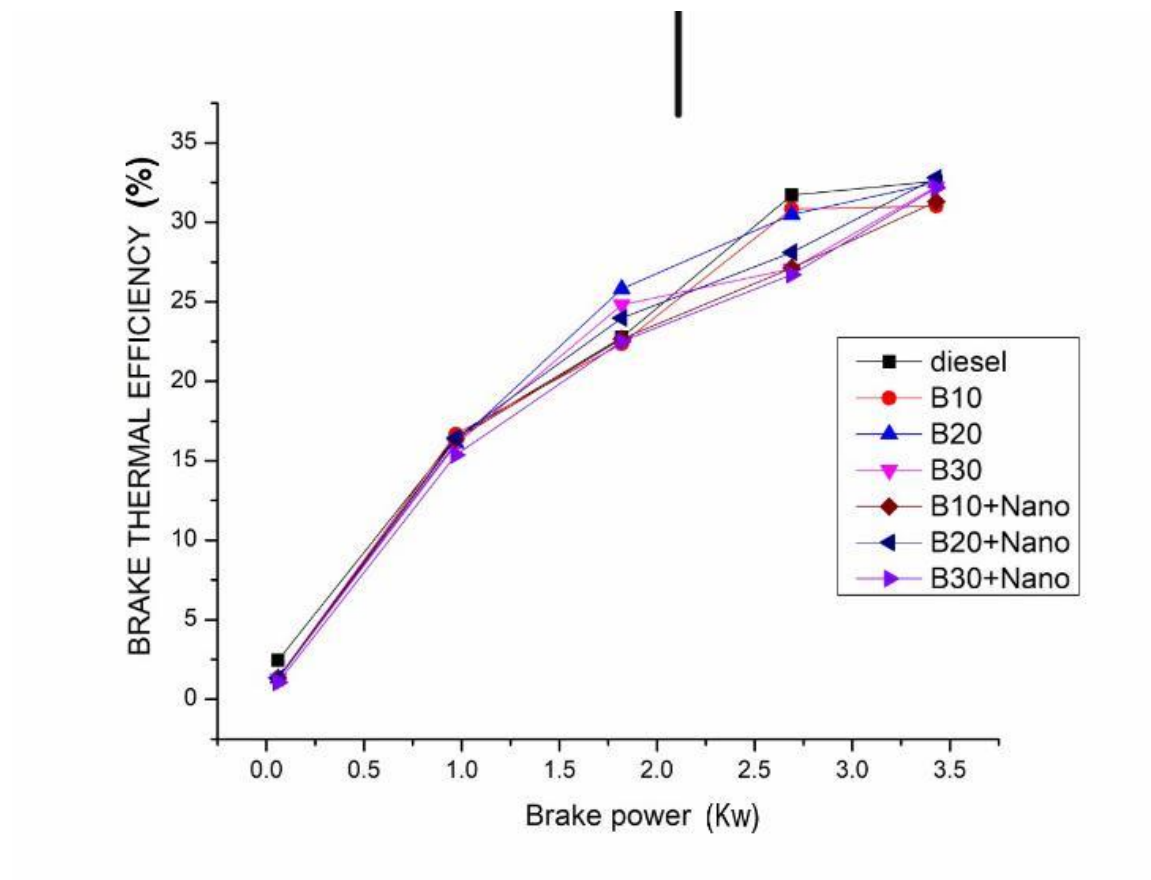


Fig 5.1 Brake thermal efficiency

5.1.2 Brake specific fuel consumption

Brake-specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. It is the rate of fuel consumption divided by the power produced. From the below it has shown that diesel has high calorific value so it will consume less fuel than other blends.

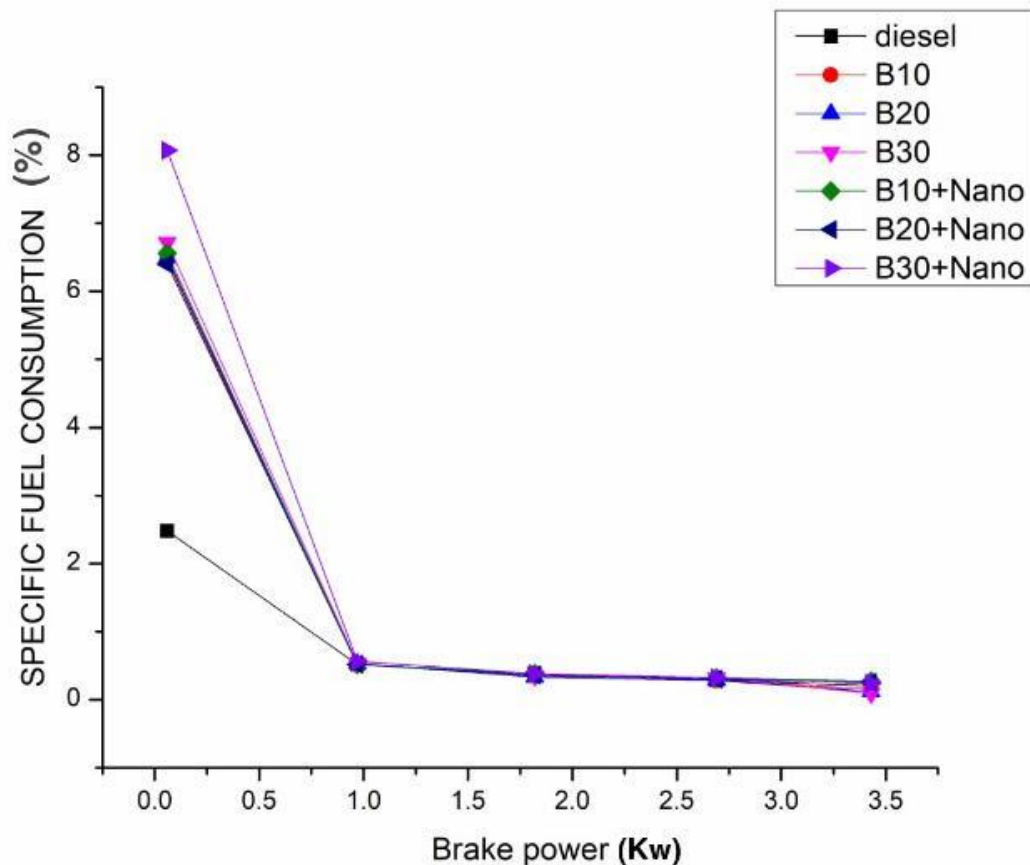


Fig 5.2 Specific fuel consumption

5.1.3 Exhaust Gas Temperature

EGT is a measurement of temperature of the exhaust gases at the exhaust manifold. As the temperature of the exhaust gas varies with the ratio of fuel to air entering the cylinders, it can be used as a basis for regulating the fuel/air mixture entering the engine.

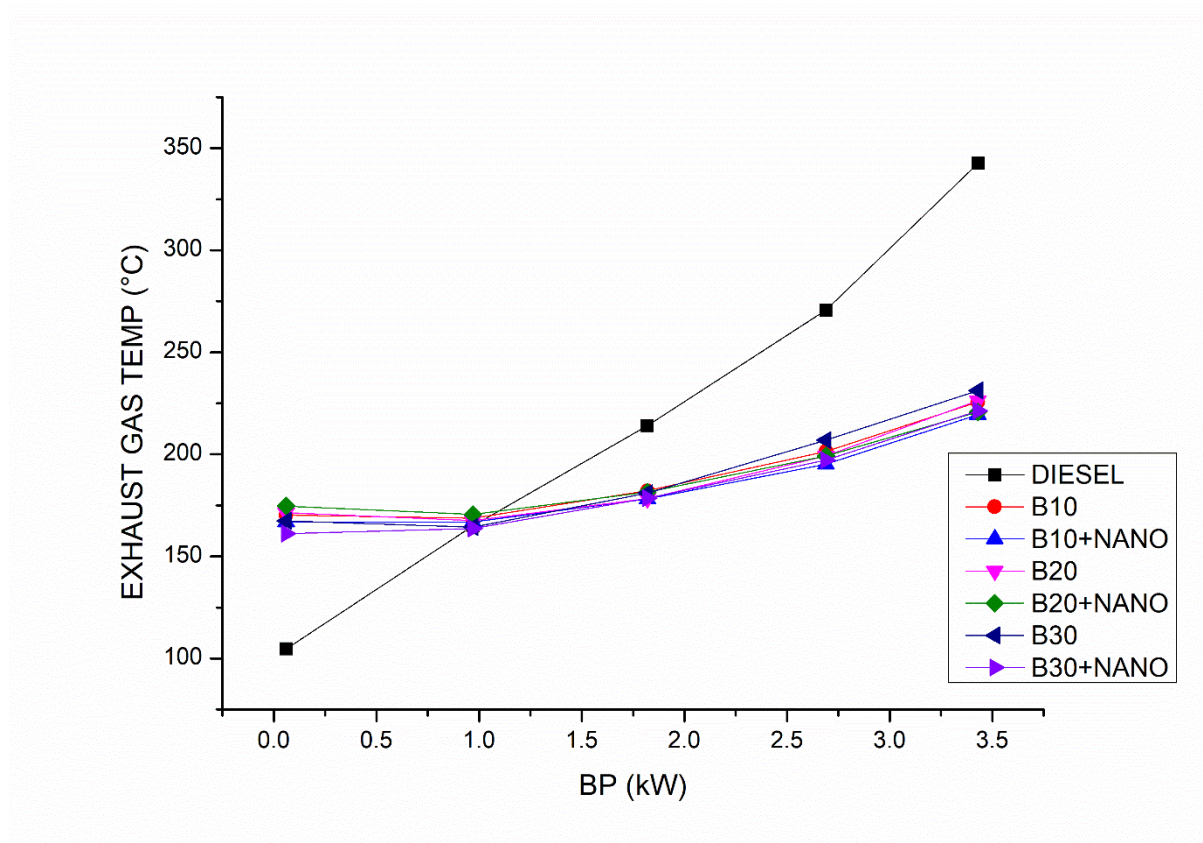


Fig 5.3 Exhaust gas temperature

5.2 EMISSION CHARACTERISTICS

Emission characteristics like CO emissions, CO₂ emissions, NO_x emissions, HC emissions and also smoke emissions results are studied and discussed in this section by drawing the graphs for all the emission levels at different brake power.

5.2.1 CO Emissions

Carbon monoxide (CO) which is colourless, odourless, tasteless and toxic air pollutant which pollutes the environment. It happens due to an insufficient supply of oxygen. Inefficient mixing of the air-fuel mixture, inadequate supply of oxygen and less oxygen concentration leads to the emission of carbon monoxide.

From the below graph it has shown that diesel emits CO emission but for the rest fuel blends there was no emission of carbon monoxide

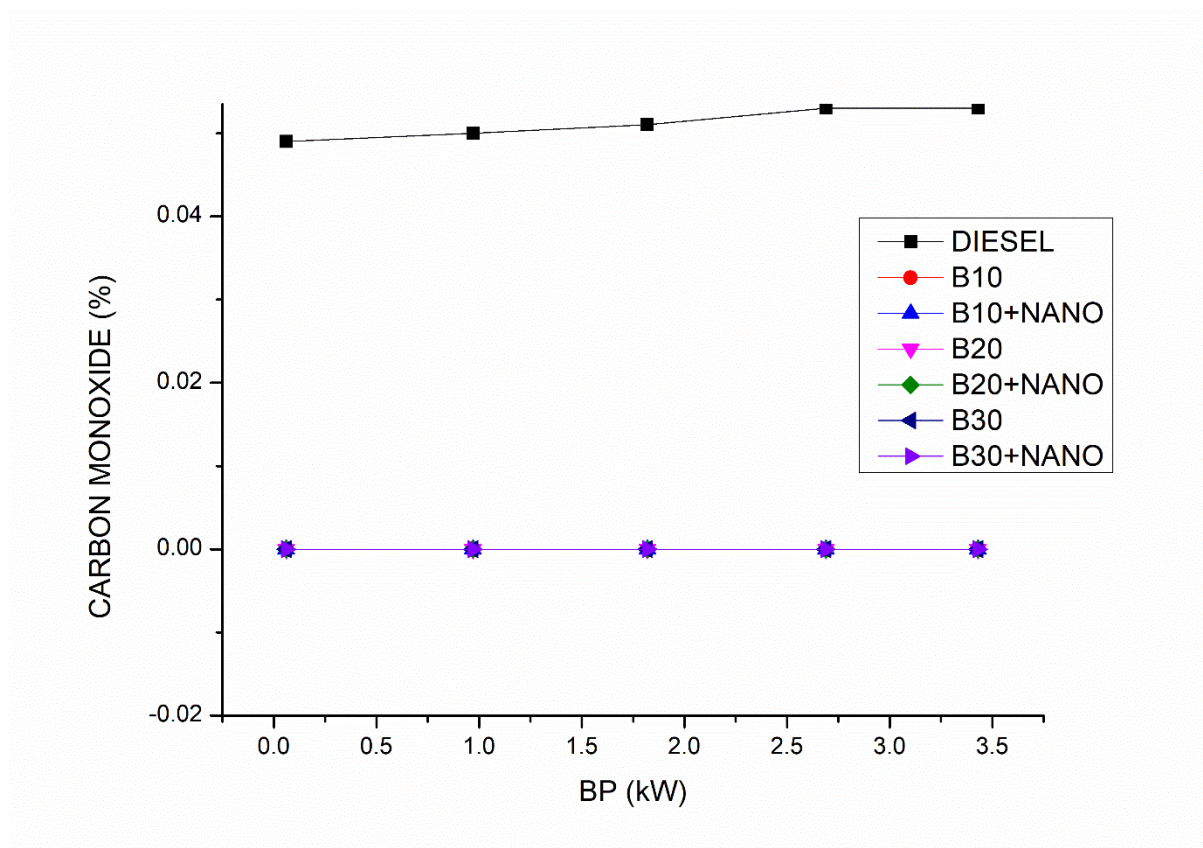


Fig 5.4 CO Emission

5.2.2 Carbon dioxide Emissions

The emission of CO₂ shows the complete combustion of the air-fuel mixture. It shows that there was an adequate supply for oxygen for the fuel which was sprayed into the chamber. CO₂ is one of the basic greenhouse gases which gets released into the atmosphere along with the other exhaust gases. From the above it is shown that for the diesel the carbondioxide emission is more but for fuel blends B10+nano shows the less emission of carbondioxide.

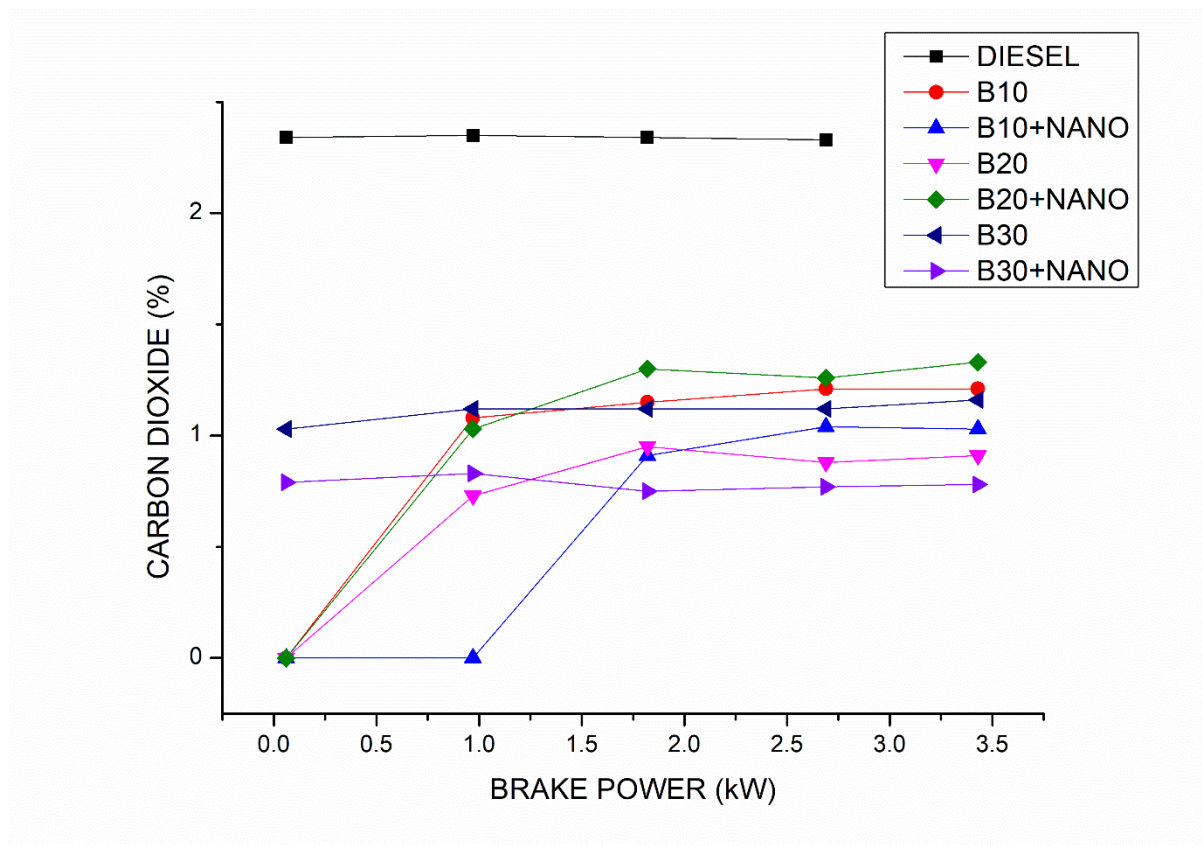


Fig 5.5 Carbondioxide emission

5.2.3 Nitrogen dioxide Emissions

Flame temperature and long retention time are the reasons for NO_x formation in CI engines. The biodiesel blends contain more oxygen than straight diesel. High NO_x emissions can emit when the engines air-fuel mixture is very lean. The leak in the fuel system, problem with the vehicles oxygen sensor can leads to the release of the oxides of nitrogen emissions into the atmosphere

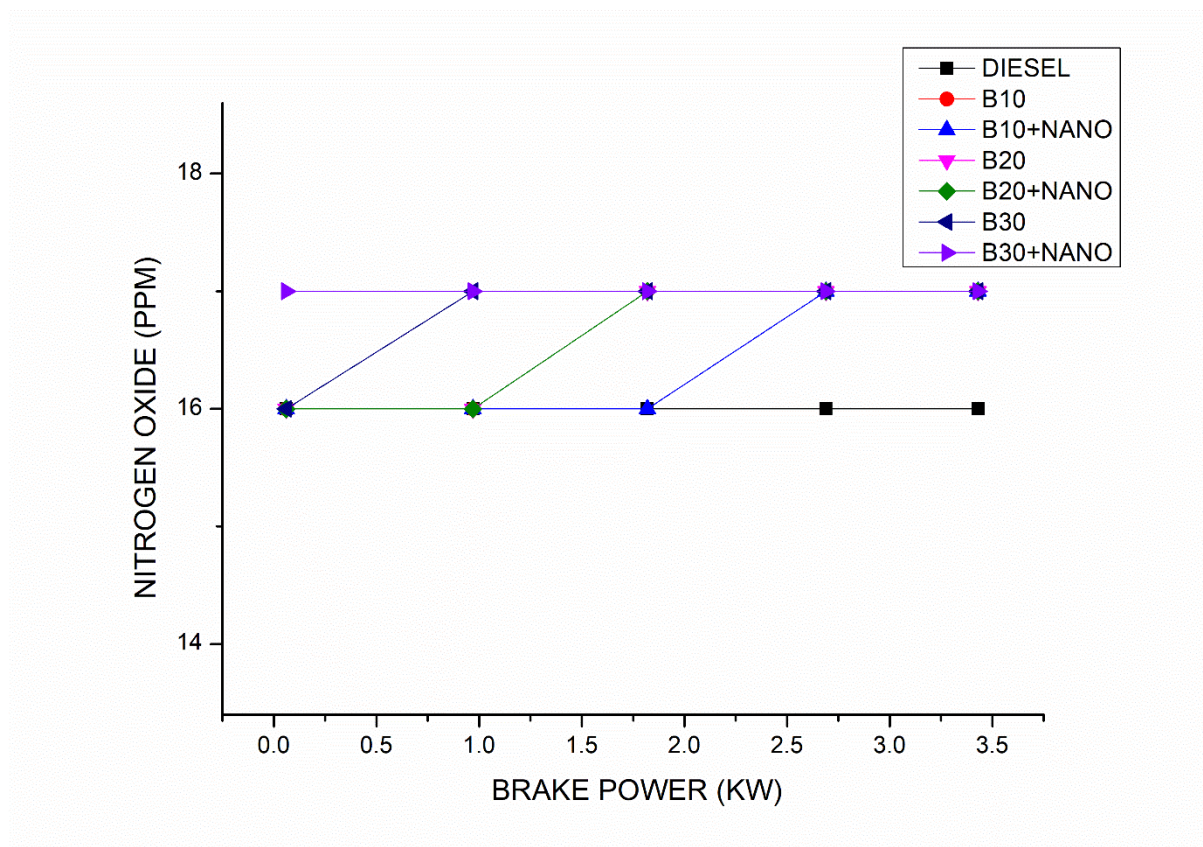


Fig 5.6 Nitrogen oxide emission

5.2.4 Hydrocarbon Emissions

Hydrocarbon emissions are due to incomplete combustion of fuel in the combustion chamber. The poor ignition of the fuel will release the high number of hydrocarbons into the atmosphere. The formation of the hydrocarbons is due to the very rich and lean mixtures during combustion. Over mixing of the air-fuel mixture beyond the lean flammability limits will also lead to the emission of hydrocarbon gas to the atmosphere and this leads to the pollution in the atmosphere. the commercially available diesel or petrol diesel emits a large amount of HC when compared to the biodiesel fuel blends

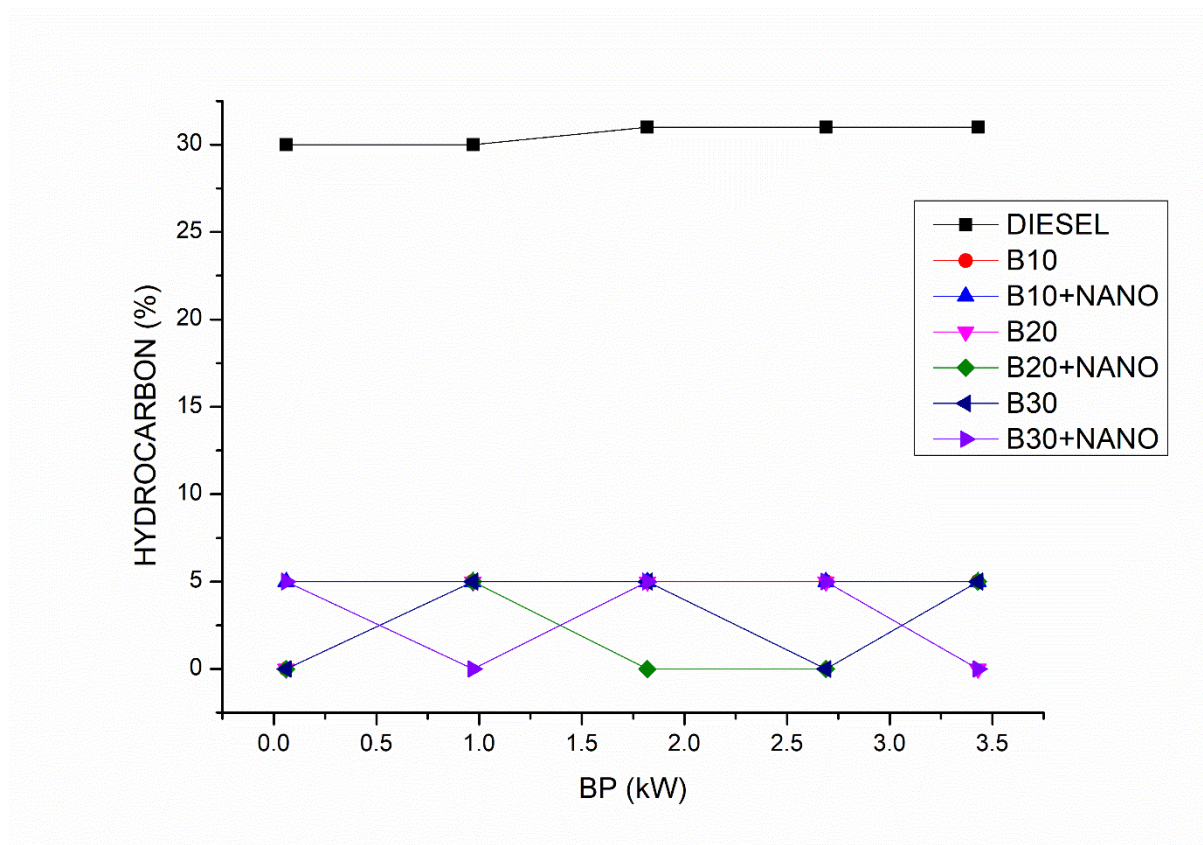


Fig 5.7 Hydrocarbon emission

CHAPTER 6

SUMMARY AND CONCLUSION

- The watermelon seed biodiesel is prepared successfully according to the standards.
- The high performance blend was prepared and tested physical and chemical properties.
- The high performance fuel blend is tested at different combustion chambers at different brake power.
- The brake thermal efficiency is found to be high for diesel.
- NO_x emissions was lowest in compared to

diesel against all the fuel blends.

- Hydrocarbon emission was higher for diesel but lower for fuel blends.

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