

EXPERIMENTAL INVESTIGATIONS ON 4-STROKE DI DIESEL ENGINE USING METHYL ESTERS OF POLANGA OIL AND THYME OIL AT DIFFERENT INJECTION TIMINGS,INJECTION PRESSURES.

Submitted in partial fulfilment of the requirements
For the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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



SATHYABAMA

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

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **G. VENKADESH PRASAD (37150210), HAMILTON V DE PAUL (37150070)**, who carried out the project entitled "**Experimental investigations on 4-stroke di diesel engine using methyl esters of polanga oil and thyme oils at different injection timings, injection pressures**". Under our supervision from September 2020 to April 2021.

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We **HAMILTON V DE PAUL (37150070), G.VENKADESH PRASAD (37150210)** hereby declare that the project report entitled “**Experimental Investigations on 4-stroke DI Diesel Engine using Methyl Esters of Polanga oil and Thyme oils at Different injection timings, Injection Pressures.**” Done by me under the guidance of **Mr. J.SENTHILKUMAR,M.E.,(Ph.D)** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree In Mechanical Engineering.

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ABSTRACT

Air pollution generated from mobile sources is a problem of general interest. Vehicle population is projected to grow close to 1300 million by the year 2030. Diesel engines are used mostly for industrial purposes as they provide higher torques at lower speeds enabling them to run heavy tasks. Due to incomplete combustion in the diesel engine, there are a number of incomplete combustion products like CO, CO₂, HC, NO_x, particulate matters etc. The proposed project aims to investigate experimentally the performance, combustion and emission characteristics of DI Diesel engine using Diesel blends of Polanga oil methyl ester and Thyme oil methyl ester. And also this project aims to investigate the performance of dual fuel mode operated existing DI Diesel engine.

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LIST OF ABBREVIATIONS

SFC	Specific Fuel Consumption
BTHE	Break Thermal Efficiency
CO	Carbon monoxide
BP	Break power
HC	Hydro carbon
NO _x	Nitrogen oxide
DI	Direct Injection
NaOH	Sodium hydroxide
KOH	Potassium hydroxide
BMEP	Brake mean effective pressure
IMEP	Indicated mean effective pressure
ZrO ₂	Zirconium oxide
CV	Calorific value
RPM	Revolution per minute
O ₂	Oxygen
PPM	Parts per million

CHAPTER 1

INTRODUCTION

Major research is focused on fuel consumption and emission reduction in the past few years. There is growing interest on alternative fuels due to volatile fossil fuel price and depletion. In many applications like Transportation, Power generation, Marine applications etc., diesel Engines are being used as a major source. During last century, the uses of fossil resources are increasing due to significant growth of population and change in life style. This causes crises of fossil fuel depletion for the diesel engines there is an urgent need for suitable alternative fuels. In this project we will examine the use of Polanga oil and Thyme oil in four stroke DI diesel engine. With diesel and different blends of Polanga oil and Thyme oil, an attempt will be made to the performance and emission characteristics of a diesel engine. The use of biodiesel leads to reduction in HC and CO emissions and increase in fuel consumption. When the Nano particles are used there will be an increase in thermal efficiency and decrease in nox emission. When biodiesel is used then there will be less emission compared to diesel. The effect of using vegetable oil-based additive combined with metal-based additive on exhaust emission of four Stroke DI diesel engine fuelled with biodiesel.

1.1 BIOFUELS

The biofuels are produced from biomass. The biofuels may be in solid (vegetables wastes, and a fraction of the urban and industrial wastes) liquid (bio alcohols and biodiesel) or gaseous (biogas and hydrogen) form. The first-generation biofuels are produced from cereal crops (e.g. wheat, maize), oil crops (e.g. rape, palm oil) and sugar crops. Biodiesel is a first-generation biofuel. Other first-generation biofuels are bioethanol, biogas and straight vegetable oils. Second generation biofuels are produced from lignocellulos materials. The syngas produced by gasification of biomass is used as precursor of second-generation biofuels like Biomass to liquid (BTL), Bio Dimethyl ether / Methanol, Biosynthetic Natural Gas and bio hydrogen. Bio- oil, produced by pyrolysis of biomass, and cellulosic ethanol are also second generation biofuels.

1.2 BIODIESEL

The biodiesel refers to methyl or ethyl esters obtained by transesterification of animal fats or vegetable oils. Biodiesel can be blended with Petro diesel. In the case of mixtures, the respective proportion of biodiesel in Petro diesel should be indicated. B20 means a mixture 20% biodiesel and 80% petroleum diesel. B100 is pure biodiesel. Two main groups of raw materials for production of biodiesel can be distinguished vegetable oil and waste cooking oil. The used cooking oil is an important waste and it can be used for biodiesel production. However, the actual tendency is the utilization of pure vegetable oils cultivated for energetic use. The main raw materials to elaborate biodiesel are Conventional vegetable oils of sunflower, rapeseed, soybean, coconut and palm.

1.2.1 SOLID BIO-FUELS

The conversion of solid bio-fuels to energy is quite a traditional human activity – from the fire used in pre-historic times to modern cooking stoves, and electricity generation from biogenic residues burnt to generate steam for high-pressure turbine power plants. Biomass gasification technology based on solid bio-fuels has become commercially viable in recent times for both - power generation and process heat applications in industry. Realizing the potential of gasification technology to meet the distributed power energy and industrial applications for process heat in Small and Medium Enterprises (SMEs), a number of large projects are under implementation in several countries. Interestingly, the market enterprises (SMEs), a number of large projects are under implementation in several countries. Interestingly, the market introduction of such technologies in developing countries is far more rapid such as India than in industrialized ones Medium-to-large cogeneration using bio-fuels is already in the market, and could benefit from gasification developments, especially for industrial process heat, and on-site cogeneration. With “hybrid” schemes and “bio-refineries” for multiple outputs becoming available in the next decade, power and fuel markets might well overlap or even merge, allowing the bio-energy industry to optimize their outputs according to market development, and revenue opportunities.

With the emerging bio- and thermo chemical conversion systems for bio-energy, the bioenergy power and heat sector will be coupled more closely to the transport sector. Indirectly, this will also couple the commodity prices for traditional agricultural and forestry products with the energy sector. This development would mean that the agro and forestry product industries will have to consider the developments in the bio-fuel markets far more closely, and then decide whether to become active in those markets. For this, there is a clear need of support for the decision-making process, especially for SMEs.

1.2.2 LIQUID BIO-FUELS

Bio-ethanol and bio-diesel have emerged as dominating liquid bio-fuels on the global scale in replacing fossil fuels (i.e. gasoline and diesel) not only in the transport sector, but also with huge potential for heat and electricity generation. Bio-ethanol from biomass as a substitute for gasoline is currently the main biofuel globally as it has proven efficiencies, and established economics. Suitable biogenic feedstock contains high shares of sugar, or starch, which is catalyzed into simple sugars, and then fermented into ethanol. Sugar cane in particular stands as the feedstock that already provides a large amount of ethanol in Brazil. Other crops, which can be converted into ethanol, are cassava, maize, potatoes, sorghum, sugar beet and wheat. The conversion of their starch content into sugar has a high process energy demand, so that the cost of the product is quite high.

Bio-diesel is another important liquid bio-fuel oilseed-yielding plants like castor, cotton, jatropha, palm, rape, soy, etc. offer a feedstock from which Straight Vegetable Oils (SVO) can be derived by physical and chemical treatment (milling/refining). The SVO can then be processed further into Fatty Acid Methyl Esters (FAME), also known as bio-diesel. With respect to future market potentials, smaller-scale bio-fuel cogeneration systems with diesel engines using liquid bio-fuels (SVO or FAME) as inputs become attractive additional options, especially for standalone and mini-grid applications in developing countries as well as for “green” electricity generation in industrialized nations.

For developing countries, it is potentially valuable that bio-diesel can also be derived from plants such as *Jatropha*, which show comparatively low yields, but need only minor inputs so that their overall costs might be moderate if land and labour costs are low. *Jatropha* can also be grown on marginal and even degraded land, and needs only little irrigation during the first years.

1.2.3 Gaseous Bio-Fuels

Development of Biogas has reached far beyond the mere fermentation of biomass residues like dung, liquid manure, or organic household wastes: nowadays, it can be derived from “modern” bio-energy crops such as maize (or corn), wheat, and even more interestingly from industrial wastes as well as from mixed or double cropping farming systems which can integrate various “old” plant varieties into their rotation, and give net energy yields comparable to the best palm oil, or sugarcane plantations. High rate bio-methanation process has been applied in many countries to obtain biogas from industrial wastes as well as from liquid municipal wastes for use on a commercial basis to generate power or process heat. India through its nationwide programme of biogas installations proved success of their technology.

1.3 BIODIESEL PRODUCTION

The commercial method used for the biodiesel production is the transesterification (also called alcoholises). The transesterification consists on the reaction of oils or fats (triglycerides between 15 and 23 atoms, being the most common with 18) with an alcohol of low molecular weight (usually ethanol or methanol) with the presence of an alkaline catalyst (usually NaOH or KOH) to produce esters and glycerine. Normally, the reaction takes place at atmospheric pressure and 65°C of temperature. The process uses constant agitation, during an interval of time between one or twelve hours. The transesterification consists of three consecutive and reversible reactions. The stoichiometric ratio for the transesterification reaction is three moles of alcohol and one mole of triglyceride. An extra amount of alcohol is added in order to move the reaction to the methyl esters formation. Glycerine is also formed in the reaction.

1 oil/fat + 3 methanol = 3 methyl esters + 1 glycerine.

1.4 BIODIESEL FEATURES

The biodiesel properties depend on the used feedstock (new vegetable oil, waste cooking oils, animal fats, etc.). Important properties of the biodiesel are it can be used pure or blended with petro diesel in engines. It can be used in the diesel engine without any modifications. It can be stored in the same containers than Petro diesel. Prolong engine life due to the higher lubrication capacity. It improves combustion process. The biodiesel contains at least 11% oxygen. Biodiesel burns better (more completely with few fuel unburned emissions) than petroleum diesel. Less smoke is produced. The use of biodiesel can reduce the emissions of unburned hydrocarbons (HI) in a 90%. It generates employment and lubricates moving engines. It is Biodegradable. It does not contain sulphur. No sulphur emissions are emitted during the combustion. It is less inflammable compared with Petro diesel.

During the combustion biodiesel emits less harmful gases into the environment compared with Petro diesel. Biodiesel reduces the health risks associated with petroleum diesel. The use of biodiesel decreases emission of PAH (identified as cancer causing). Biodiesel is nontoxic. During the combustion of biodiesel, the CO₂ cycle is closed. The CO₂ produced during the combustion is the amount of CO₂ which the plants are able to metabolize through photosynthesis during growth. Moreover, this process implies low emissions of CO₂, due to the medium content carbon for plants is 77.8% and for animal fats is 76.1%. While, the content carbon for fossil diesel is 86.7%. The use of biodiesel can reduce the CO₂ emissions up to 50% in comparison to the use of petroleum diesel. The biodiesel transport and its storage are less dangerous than the petroleum diesel, because biodiesel has a flashpoint temperature of about 170°C in comparison of 60 to 80 °C for petroleum diesel. It is non-irritating to the skin and has a pleasant aroma.

Moreover, those advantages also other economic aspects can be taken into account biodiesel contribute to diversification of energy sources. It is an important aspect for countries without fossil fuel sources. The biodiesel contributes to agricultural and rural development.

The most important biodiesel disadvantages, in comparison with the cost and the biodiesel production is today expensive compared with Petro diesel. The biodiesel needs more additives, mainly in cold countries, due to its high cloud point. Lower long-term storage stability. The biodiesel becomes rancid due to oxidation and bacterial air. This rancidity process produces aldehydes, ketones and acids, which have strong and unpleasant odors. It is required 1.1 liters of biodiesel to replace one liter of petroleum diesel, because of their lower calorific power. High percent blends of biodiesel can soften and degrade certain types of elastomers and natural rubbers. In this case, precautions have to be taken concerning the materials in fuelling system. Biodiesel may dilute the lubricating oil of engines. The biodiesel produces more NO_x emissions than Petro diesel-a comparison of the emissions from biodiesel and Petro diesel.

1.5 ADVANTAGES OF BIO-DIESEL

Biofuels are seen as a more sustainable alternative to conventional petrol and diesel derived from fossil fuels because they come from renewable sources, which also absorb carbon dioxide (CO₂), although CO₂ will be emitted because of energy used in the harvesting and production process. Studies indicate that the overall CO₂ savings from biofuels compared to conventional petrol and diesel vary between 20% to 70% depending on the type of crop and the energy consumed in growing, harvesting, transporting and processing the crop into a fuel.

- Biodiesel is the comparatively very clean and environmentally friendly only alternative fuel.
- Biodiesel runs in any conventional unmodified diesel engine. It can be stored anywhere that petroleum diesel fuel is stored.
- Biodiesel can be used alone or mixed in any ratio with petroleum diesel fuel.
- Studies have found that the lifecycle production and use of biodiesel produces approximately between 80-100% less carbon dioxide and almost 100% less Sulphur dioxide emissions.
- β Combustion of biodiesel alone provides over a 90% reduction in total unburned hydrocarbons and a 75-90% reduction in aromatic hydrocarbons.

- Biodiesel further provides significant reductions in particulates and carbon monoxide than petroleum diesel fuel.
- Based on Ames Mutagenicity tests, biodiesel provides a 90% reduction in cancer risks.
- Biodiesel is 11% oxygen by weight and contains no sulphur. The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel while fuel consumption, ignition, power output and engine torque are unaffected.
- Biodiesel is safe to handle and transport because it is as biodegradable as sugar, 10 times less toxic than table salt and has a high flashpoint of about 125C compared to petroleum diesel fuel, which has a flash point of 55C.
- Biodiesel can be made from renewable oilseed crops such as soybeans, rapeseed, cottonseed and mustard seed and non-edible oilseeds.

1.6 PROCESS DESCRIPTION

The biodiesel is produced by transesterification of oil using methanol (alcohol) and NaOH (catalyst). The process steps are,

- i. The vegetable and waste cooking oils are received. They are transported to the plant with trucks.
- ii. The oils are stored in outside tanks of the plant.
- iii. Drying and pre-treatment of the oil.
- iv. The oil transesterification. The reactor is scheduled by 8000 hours per year, with a daily biodiesel production of 200 tons per day. The process starts with the refined oil. In the reactor, the oils are mixed with the methanol, in excess, NaOH (catalyst)
- v. The reaction products are neutralized with a mineral acid. Methanol in excess is evaporated, and then condensed and stored to be reused in the next cycle.
- vi. The biodiesel is stored in tanks with nitrogen coverage to avoid its oxidation. The truck load is performed under nitrogen injection to avoid its degradation in transport.

1.7 ESSENTIAL OILS

Essential oils are the concentrated aromatic oils of plant leaves, flowers, seeds, bark, roots, and the rinds of some fruits. They vary in strength but are always very potent, and often smell best when diluted (as in other oils, colognes, and shampoos). Those essential oils obtained from trees are generally produced by a lengthy steam distillation process applied to either the chopped wood or the leaves and branch ends of the tree.

1.8 TRANSESTERIFICATION

This process changes the molecular structure of lipid molecules and thus the physical properties. Although even refined pure plant oil (PPO) can be directly used in refitted diesel engines, biodiesel, which is created by a transesterification step, is very similar to fossil diesel and thus can be consumed in common diesel engines which are refitted with only small efforts.

Transesterification is also called alcoholysis, is the process by which the refined oil molecule is “cracked” and the glycerine is removed, resulting in glycerine soap and methyl or ethyl esters (biodiesel). Organic fats and oils are triglycerides which are three hydrocarbon chains connected by glycerol. The bonds are broken by hydrolyzing them to form free fatty acids. These fatty acids are then mixed or reacted with methanol or ethanol forming methyl or ethyl fatty acid esters (monocarbon acid esters). The mixture separates and settles out leaving the glycerine on the bottom and the biodiesel (methyl, ethyl ester) on the top. Now the separation of these two substances has to be conducted completely and quickly to avoid a reversed reaction. These transesterification reactions are often catalyzed by the addition of an acid or base. For the transesterification process, mainly the alcohols methanol and ethanol are used. Theoretically, transesterification can be also processed with higher or secondary alcohols. Considering wide variety of oils and fats that can be used to produce biodiesel, there is a greater range in the characteristics of biodiesel fuels than for ethanol fuel. Ethanol is actually one very specific molecule, whereas biodiesel is a mix of molecules that varies somewhat, depending on the initial oil or fat source used to produce the fuel.

1.9 POLANGA OIL

Polanga oil is non-edible oil extracted from seeds of tree called punnai belongs to the family clusiaceae and its botanical name is *callophyllum inophyllum*. In India, the plant is distributed in Southern coastal regions as well as nearby lowland forests. It tolerates varied kinds of soil, coastal sand, clay or even degraded soil. Polanga seed oil tree is a low-branching and slow growing tree and irregular crown. It usually reaches 8 to 20 meters in height with diameter up to 150cm. The flower is 25 millimetres and consisting 4 to 15 flowers. Flowering can occur year round but usually two distinct flowering periods are observed, in late spring and in late autumn. The fruit (the ball nut) is a round green reaching 2 to 4 centimetres in diameter and having a single large seed.



Fig: 1.9(Raw material of Polanga fruit)

The yield of kernel per tree per year is between 20 to 300 kg. The freshly extracted oil is thick dark green in colour. The polanga seed kernel contains oil 65 wt % of oil. The free fatty acid is found to be 22% by weight. The oil is extracted from the kernel by traditional expeller, which yields 750 to 850 ml per kg of seed kernel. The cost of production works out to sold in the market at Rs.25-30 per litre as per The Hindu survey report (March 26, 2015). Polanga oil contain 24% saturated acids (Palmitic and stearic) and 72.65% unsaturated acids (oleic, linoleic). The tree has been mainly used in construction of boat building. The oil is used as an ingredient in skin crème and night lamp. The flowers are pollinated by bees and other insects and fruits are dispersed by sea currents and bats.

Analysis of polanga oil purchased from local market with no additional chemical treatment for various properties have been performed in an ISO certified research laboratory based on ASTM standard test methods (Appendix C). Table 1.1 shows the measured properties of polanga oil.

Table 1.9: Properties of polanga oil

Property	Results obtained
Specific gravity @ 15/15°C	0.9374
Kinematic viscosity @ 40°C in cst	57.8
Flash point	227°C
Fire point	238°C
Cloud point	14°C
Pour point	7°C
Gross calorific value in kcal/kg	9945
Acidity as mg of KOH/gm	47.8

Polanga oil producers are adopting different production methods. Homogeneity of oil is not consistent. The price of polanga oil is dependent on the availability and polanga oil seed price. Hence polanga oil was purchased from a single large scale polanga oil producer. Quality tests for polanga oil are more expensive. Development of less expensive quality tests is to be initiated. Polanga oil is stored in plastic can. Gum formation in the form of gelatinous precipitate is observed after six week storage. Free fatty acid and water content in polanga oil contributes to the quality of blends.

1.10 THYME OIL

Thyme (*Thymus vulgaris*), an herb in the mint family, is often used as a spice in cooking. Aside from adding flavour, the herb is also believed to have medicinal properties. It is known to have anti-inflammatory, antimicrobial, and antioxidant effects that may be useful in treating everything from intestinal infections to skin conditions. Thyme can be used fresh or dried, or it can be distilled into an essential oil for aromatherapy. Thyme is also sold as a dietary supplement in liquid or capsule form. There are even thyme teas, mouthwashes, face masks, and nasal sprays.



Fig: 1.10(raw material of thyme leaves)

Thyme is best cultivated in a hot, sunny location with well-drained soil. It is generally planted in the spring, and thereafter grows as a perennial. It can be propagated by seed, cuttings, or dividing rooted sections of the plant.

Table 1.10(Properties of thyme oil)

Properties	Result obtained
Kinematic Viscosity (mm ² /s)	109.53
Density (Kg/m ³)	962.8
Fire point	335°C
Flash point	298°C
Cloud point	15.8°C
Specific gravity	0.9628
Calorific value (kJ/kg)	35684.5

The plant can take deep freezes and is found growing wild on mountain highlands. Oil of thyme, the essential oil of common thyme (*Thymus vulgaris*), contains 20–54% thymol. Thyme essential oil also contains a range of additional compounds, such as *p*-cymene, myrcene, borneol, and linalool. Thymol, an antiseptic, is an active ingredient in various commercially produced mouthwashes such as Listerine.

1.11 MAIN EXTRACTION PROCESS

At present, there are 4 main extraction technologies for wheat germ oil processing: supercritical CO₂ fluid extraction, traditional solvent extraction, low temperature pressing and subcritical low temperature extraction. But some of these methods have a lot of shortcomings.

1.11.1 Supercritical CO₂ fluid extraction

High Cost, Low Output: As its requirements for equipment are very high, supercritical CO₂ fluid extraction machine is very expensive. Besides, its output is low and difficult to adapt to large-scale production. **Traditional Solvent Extraction (Hexane)** – High processing temperature, high energy consumption, low quality of oilcakes or meals. It is a process of extracting oil at normal pressure by use of Hexane. The temperature of extracting process and desolventizing process is high, resulting in high rate of protein degeneration of oilcakes or meals. **Low Temperature Oil Pressing** - High residual oil content in oil cakes / meals; high impurities and moisture content. Direct squeezing or expelling is not suitable for low oil yield materials such as Polanga and Thyme oil.

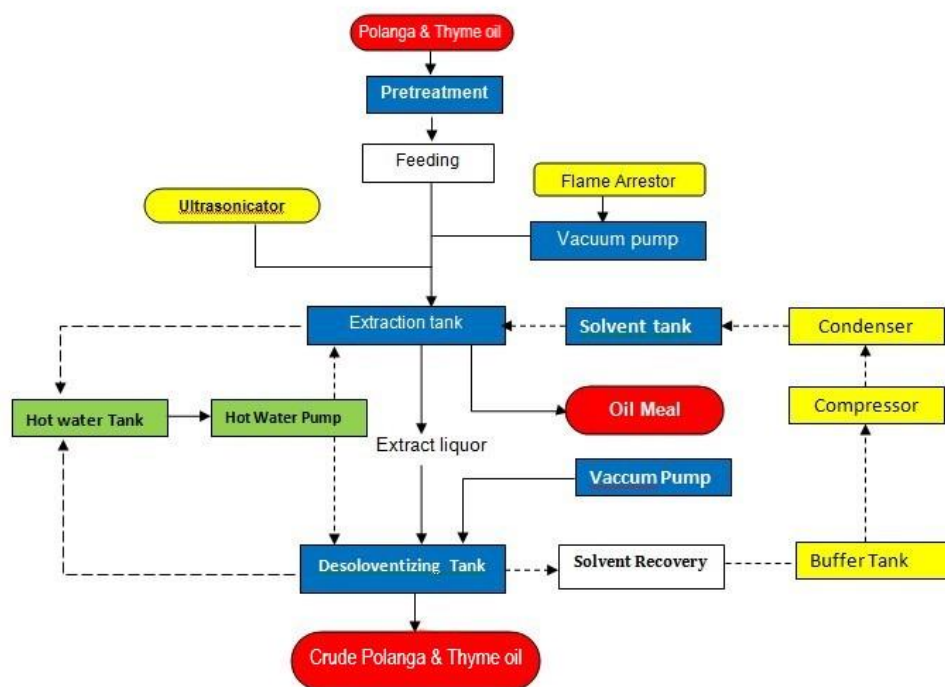


Fig 1.11.1 The Extraction Process of polanga oil and thyme oil

1.12 ADVANTAGES OF SUBCRITICAL EXTRACTION TECHNOLOGY

Subcritical Extraction Technology is a kind of pressurized (0.3-0.8 MPa) fluid extraction process. The extracting agent exists in the form of gas under normal pressure, while under critical pressure it exists in the fluid state. Under critical pressure, the molecular diffusion ability of extraction solvent is enhanced, transfer rate is accelerated, and permeability and dissolving capacity is improved significantly. Besides, as it is a kind of low temperature extraction technology, the natural active ingredient in extraction materials are fully retained and protected.

The extraction process is cut off from the air, which can avoid oxidation reaction of special materials and help getting high grade oil products just as supercritical extraction. But the extraction pressure is much lower than supercritical extraction, which is a good thing that makes the equipment price is much lower and also make it feasible for industrialization scale production.

1.13 WHY POLANGA OIL AND THYME OIL

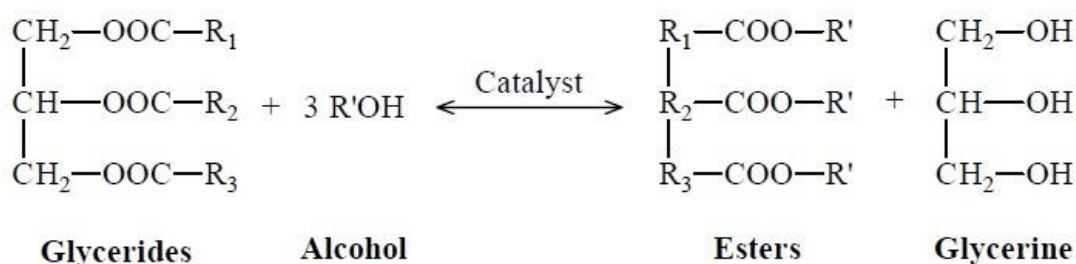
For this project we choose polanga oil and thyme oil. Polanga oil is made from crushed polanga seed and thyme oil is grind from thyme leaves. We had mixed the polanga oil and thyme oil which is new combination of Bio-diesel. The transesterification process is the reaction of oil with an alcohol to form esters and glycerol. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can in turn, affect the characteristics of the biodiesel during the esterification process.

Moreover, its natural vitamin E content in all vegetable oil. It also plays an important role in the regulation of body electrolyte balance and blood pressure, lower cholesterol, prevent disease of heart head blood-vessel. It has recognized as a kind of "golden oil" for nutritive health.

The synthesis of biodiesel fuel from the agricultural oils of polanga and thyme oil occurred through four main steps. Initially, the polanga and thyme oil were put through a transesterification process to produce polanga and thyme methyl ester. Secondly, any atmospheric oxygen was removed from the fatty acid methyl esters (FAMES) through vacuuming and a freeze pump-thaw cycle.

Then, the samples underwent pyrolysis by heating in a furnace set at 675°C (948.15K) for time durations of either 15, 30, 60, or 120 minutes. Finally, the samples were analysed via gas chromatography/mass spectrometry (GC/MS) to detect hydrocarbons numbers and percent composition.

Fatty Acid Methyl Ester Initially, the same process is utilized to convert the triglycerides in Polanga and Thyme oil to their fatty acid methyl-ester derivatives. Transesterification involves a triglyceride reacting with methanol and potassium hydroxide catalyst to produce glycerol and methyl ester, as shown by Equation 1



A sample size of 10 mL was pipetted into a dry 50 ml glass flask already containing a magnetic stirrer. The 50 ml flask and its contents were then nestled on top of an aluminium stand which was placed on a hot plate stirrer. The aluminium stand also contained a thermometer in order to accurately measure temperature. A water-jacket condenser was then attached to the 50 ml flask. Dryness is absolutely essential as any moisture in the system will consume some of the catalyst and decrease the rate of the transesterification. In another 10 ml volumetric flask, 0.1 grams of KOH (acting as catalyst) was mixed with approximately 2 ml of methanol until all of the KOH dissolved. The methanol/KOH mixture was quickly added to the oil and stirred vigorously for 30 minutes at 55°C using the hot plate stirrer. All the liquid in the flask was then transferred to a 15 mL centrifuge tube, capped, and centrifuged for 20 minutes. The transesterification reaction produced two visible layers, with the bottom layer containing glycerine, and the top layer containing the methyl ester (biodiesel).

The top layer, which contained the biodiesel, was poured into another 50 ml flask and heated for 30 minutes at 70°C, followed by a 20 minute centrifugation. The top layer was then separated again and placed in a vial to prepare for the freeze-pump thaw cycle (Karaosmanoglu et al., 1996; Lang et al., 2001; Kondamudi et al., 2009).

1.14ENGINE EXHAUST EMISSION PARAMETER

- a) Unburnt hydrocarbon
- b) Oxides of carbon
- c) Oxides of nitrogen
- d) Oxides of Sulphur
- e) Particulates, soot and smoke

The first four are common to both SI and CI engines and the last two mainly from CI engines. The main non-exhaust emission is the unburnt hydrocarbons from fuel tank and crankcase blow-by.

For, HC emissions also increase due to poor combustion and misfire. The generation of nitrogen oxide emissions is a function of the combustion temperature, highest near stoichiometric conditions when temperatures are at a peak value. Maximum NO_x emissions occur at slightly lean conditions, where the combustion temperature is high and there is an excess of oxygen to react with the nitrogen.

1.14.1 Hydrocarbon (HC)

CI engines operate with an overall fuel lean equivalence ratio; CI engines have only about one-fifth the HC emissions of an SI engine. Diesel fuel has a higher molecular weight on an average as compared to gasoline blend. Some HC particles condenses onto the surface of the solid carbon soot that is generated during combustion, most of this is burned as mixing continues and the combustion process proceeds. The HC components condensed on the surface of the carbon particles in addition to the solid carbon particles themselves, contribute to HC emissions of the engine. CI engine has a combustion efficiency of only 2% of HC fuel being emitted. CI engines also have HC emissions for some of the same reasons as SI engines do such as wall deposit absorption, oil film absorption, crevice volume.

1.14.2 Carbon monoxide (CO) emission

Carbon monoxide is a colourless and odourless gas but a poisonous gas. It is generated in an engine when it is operated with a fuel - rich equivalence ratio. When there is not enough oxygen to convert all carbon-to-carbon di oxide, some fuel is not burned, and some carbon ends up as Carbon monoxide. Not only CO is considered an undesirable emission, but it is also representing lost chemical energy. Maximum CO is generated when an engine runs rich. Poor mixing, local rich regions, and incomplete combustion will also be the source for CO emissions.

1.14.3 Oxides of Nitrogen (NO_x)

Exhaust gases of an engine can have up to 2000 ppm of oxides of nitrogen. Released NO_x reacts in the atmosphere to form ozone and is one of the major causes of photochemical smog. NO_x is created mostly from nitrogen in the air. Nitrogen can also be found in the fuel blends. There are number of possible reactions that form NO. All the reactions are probably occurring during the combustion process. Gases that are stable at low temperatures but become reactive and contribute to the formation of NO_x at high temperatures include oxygen and water vapor. In addition to temperature, the formation of NO_x depends upon the pressure and the air- fuel ratio.

1.15 PERFORMANCE PARAMETER

1.15.1 Compression ratio

At the end of the compression stroke, there is an increase in the compression temperature of the air with increase in compression ratio. Also, at the minimum auto ignition temperature of a fuel decreases due to increased density of the compressed air. This results in a closer contact between the molecules of fuel and oxygen reducing the reaction time.

1.15.2 Engine speed

The delay period could be given either in the terms of absolute time or in the terms of crank angle degree. Decrease in delay period in terms of crank angle degree with increase in the engine speed in a variable speed operation with a given fuel. In degrees of crank travel in delay period increases as the engine operates at higher

rpm. The fuel pump is geared to the engine, and hence amount of fuel injected during the delay period depends on the crank degree.

1.15.3 Output

With an increase in engine output the air fuel ratio decreases, operating temperature increase and hence delay period decreases. The rate of pressure rise is unaffected, but the peak pressure reached may be high.

1.15.4 Injection timing

The effect of injection advance on the pressure variation for three injection advance timings of 9, 18, 27 degrees before TDC. The injected quantity of fuel per cycle is constant, which depends upon the beginning pressure and temperature of the injection.

1.15.5 Quality of fuel

Self-ignition temperature is the most important property of fuel, which affects the delay period. In addition, fuels with higher cetane number give lower delay period and smoother engine operation. Other properties of the fuel, which affect the delay period, are volatility, latent heat, viscosity and surface tension.

1.15.6 Engine Brake power

Engine brake power (P) is delivered by engine and absorbed load. It is the product of torque and angular engine speed where P is engine brake power in kW; N is angular speed of the engine in rpm as:

$$P = \frac{2\pi NT}{60000}$$

1.15.7 Brake specific fuel consumption

Brake specific fuel consumption (BSFC) is the comparison of engine to show the efficiency of the engine against with fuel consumption of the engine in kg/kW/hr. where (mf) is the fuel consumption rate in kg/hr. as:

$$BSFC = \frac{\text{Fuel consumption rate}}{\text{Engine brake power}}$$

1.15.8 Break thermal efficiency

The percentage of brake thermal efficiency of the engine is related to engine brake power and total energy input to the engine.

$$\text{Efficiency} = \frac{\text{Brake power} \times 3600}{\text{Fuel consumption rate} \times \text{higher calorific value}}$$

1.15.9 Intake pressure and temperature

Increase in intake temperature increases the compressed air temperature resulting in reduced delay period.

Increase in intake pressure or supercharging reduces the auto ignition temperature and hence reduces the delay period.

1.16 NOISE PARAMETER

1.16.1 Exhaust system noise

The exhaust system noise includes the noise from exhaust gas pulses leave the muffler or trail pipe and noise emitted from vibrating surface of the exhaust system component. Noise emitted from the surface of exhaust system component result from two different type of excitation force. Those generated by the pulsating exhaust Gas flow and thus transmitted from the vibrating engine to exhaust system component.

1.16.2 Intake System Noise

Intake system noise include generated by the flow of air through the system air inlet and noise emitted from the vibrating surface component. In many instance in engine air cleaner will provide significant attenuation of intake air noise. If additional attenuation required, an intake air silencer can be added to the system. To minimize intake system surface radiated noise, proper design, selection and mounting intake system component are essential.

1.16.3 Engine Surface of Noise

Engine surface noise refers to sound emitted from vibrating surface of engine component and accessories and other thus item included in the engine exhaust.

Intake and cooling system techniques used to reduce engine surface radiated noise include a reduction in running clearance and machining tolerances of the engine. Component acoustical treatment or redesign of engine component use of acoustic treated shields and vibrating isolation and damping of engine covers and diesel engine than for gasoline engine turbo charging of a diesel engine can result in some reduction of engine surface radiated noise at high engine load.

CHAPTER 2

LITERATURE SURVEY

1. Madhavarao Buddepu (2011)

Studied the *In-Vitro* Sunscreen Activity of Essential Oil extracted in soxhlet apparatus using hexane and esterifies with methanol from dried seed of *Pongamia Pinnate* (L.) plant. The extract was found to be highly effective in the UVA region and the known standard drug PABA showed its protective action in the UVB and UVC regions and AVOBENZENE showed highly effective in the UVA region. As the extracts of the seed of the plant showed good absorbance throughout the UV region, the photo absorptive compounds in the seed can be isolated and purified and can be used to formulate highly effective sunscreen preparations.

2. Badole et al (2009)

studied the antihyperglycaemic activity of aqueous (PPSBAQE) and petroleum ether (PPSB-PEE) extract of stem bark *Pongamia pinnata* in alloxan induced diabetic mice. Based on oral toxicity data, PPSBAE showed no mortality in normal mice up to 5,000 mg/kg. PPSBAE was administered as three doses (i.e., 100, 200 and 400 mg/kg) to diabetic mice, and the serum glucose level and body weight were measured. The onset of serum glucose reduction was observed at 2 h (130.32 mg/dl), peak at 4 h (151.79 mg/dl) and sustained at 6 h, but waned at 24 h. In the subacute study, maximum reduction (305.72 mg/dl) in serum glucose was observed at a dose of 400 mg/kg on day 28. An oral glucose tolerance test (OGTT) was carried out after administration PPSBAE (200 mg/kg) in non-diabetic mice previously loaded with 2.5 g/kg, per oral of glucose. The PPSBAE (200 mg/kg) showed increased glucose threshold in non-diabetic mice.

3. Vismaya et al (2011)

Studied the gastroprotective properties of Karanj seed and found promising results for the treatment of gastric ulcers. Karanjin, a furano-flavonoid has been evaluated for antiulcerogenic property by employing adult male albino rats. Karanjin (>95% pure) was administered to these rats in two different concentrations, i.e. 10 and 20 mg/kg. Ulcers were induced in the experimental animals by swim and ethanol stress. Serum, stomach and liver-tissue homogenates were assessed for biochemical parameters. Karanjin inhibited 50 and 74% of ulcers induced by swim stress at 10 and 20 mg/kg, respectively. Gastric mucin was protected up to 85% in case of swim stress, whereas only 47% mucin recovery was seen in ethanol stress induced ulcers. H⁺K⁺-ATPase activity, which was increased 2-fold in ulcer conditions, was normalized by Karanjin in both swim/ethanol stress-induced ulcer models. Karanjin could inhibit oxidative stress as evidenced by the normalization of lipid peroxidation and antioxidant enzyme (i.e. catalase, peroxidase and superoxide dismutase) levels. Karanjin at concentrations of 20 mg/kg, when administered orally for 14 days, did not indicate any lethal effects. There were no significant differences in total protein, serum glutamate pyruvate transaminase, serum glutamate oxaloacetate transaminase and alkaline phosphatase between normal and Karanjin-treated rats indicating no adverse effect on major organs. During treatment schedule, animals remained as healthy as control animals with normal food and water intake and body weight gain.

4. Tajidin et al., (2012)

Reported that the effects of three maturity stages at harvest of Polanga and Thyme oil on essential oil, chemical composition and citral contents. The Polanga and Thyme oil plant was planted using a randomized complete block design with four replications, at the University Agriculture Park, University Putra Malaysia. The plants were harvested at 5.5, 6.5, and 7.5 months after planting. After harvest, the essential oil, chemical composition and citral contents were analysed using gas chromatography-mass spectrometry (GC-MS) analysis. Sanjay Patil and Akarte., (2012) presented that biodiesel as an alternative to diesel could reduce the dependency on petroleum products and the pollution problem. The physical properties of the fuel such as viscosity, volatility and flash point also affect the combustion process, thereby engine performance. Specifically, atomization of the fuel during the injection is attributed to higher viscosity of biodiesel. Injected fuel droplets get smaller as the injection pressure increases which contributes to better atomization of the fuel. Meiyappan Venkatesan., (2013) stated that investigation test were carried out to examine the performance and emissions of a direct injection diesel engine blended with Jatropa bio-diesel prepared with methanol to get jatropa oil methyl ester (JOME). Venugopal et al., (2014) found that plant species, like Polanga and Thyme oil (*cymbopogon citratus*) is discussed as source of oil for bio-diesel production. The bio-diesel that is produced from Polanga and Thyme oil through Transesterification process is used as a fuel. Performance test was conducted and compared with diesel.

5. AvinashAlagumalai., (2015)

Stated that the development of alternate fuels for use in internal combustion engines has traditionally been an evolutionary process in which fuel-related problems are met and critical fuel properties are identified, and their specific limits defined to resolve the problem. Murat KadirYesilyurt., (2019) found that the effect of fuel injection pressure on the performance and emission characteristics of a diesel engine fuelled with waste cooking oil biodiesel (WCOB) and its 5-30% (v/v) blends with diesel fuel were investigated and compared with diesel fuel. Materials and methods to select the suitable non edible oil for the experimental investigation. To select the suitable method for convert the biodiesel from Polanga and Thyme oil. To select the suitable mixing proportion of Polanga and Thyme oil blends with diesel fuel. The physical properties of the Polanga and Thyme oil oil biodiesel blends are shown. To select the suitable injection pressure for enhance the diesel engine performance and emission. The biodiesel was extracted through transesterification process. The physical and chemical properties of the Polanga and Thyme oil biodiesel were tested through ASTM standards and compared with diesel fuel. The Polanga and Thyme oil biodiesel was blended with diesel by various proportions such as B20, B40, B60, B80 and B100. The injection pressure was changed with 200, 210, 230, 240 bar and experimentally investigated the performance and emission characteristics. The experimental investigation were conducted on a single cylinder, water cooled, four stroke, Kirloskar TV-I diesel engine. In phase I, the investigations were conducted with various blends of Polanga and Thyme oil biodiesel and found that optimum blend for further investigations. In Phase II the optimum blend of Polanga and Thyme oil biodiesel (B20) was investigated with changing injection pressure and studied the performance, emission characteristics of test engine. The investigations were conducted with different loads and maintained 1500 rpm constant speed of the engine.

CHAPTER 3

AIM AND SCOPE OF WORK

3.1 AIM

The aim of this experimental study is to find the optimum performance and with low emission characteristics biofuel with the help of diesel blend of polanga oil methyl ester fuel and with diesel blend of thyme oil methyl ester fuel.

3.2 SCOPE OF WORK

The present study involves evaluating the performance of DI diesel engine fueled with diesel blends of polanga oil methyl ester fuel and diesel blends of Thyme oil methyl ester fuel for different injection parameters such as fuel injection timing and fuel injection pressure.

CHAPTER 4

MATERIALS AND METHODS

4.1. MATERIALS

The crude polanga oil and thyme oil collected from a local supplier to produce biodiesel. The two Nano additives used in this study were zirconium oxide (ZrO_2). The chemicals used for transesterification process are methanol, sulphuric acid as acid catalyst and potassium hydroxide as alkali catalyst. Table 4.1 shows the properties of Raw material of polanga and thyme oil.

4.2. BIODIESEL PRODUCTION

Crude oil contains 13.2% FFA by weight shows in table 4.1, so it cannot be directly treated with alkali-based catalyst and a 2-stage transesterification is required.

4.2.1. Stage 1: Esterification using acid catalyst

In this stage, the C.I oil having free fatty acid of triglycerides reacts with methanol and acid catalyst (sulphuric acid) to produce the ester. This stage of transesterification is carried out with a 16:1 M ratio of methanol to C.I oil along with 1% by weight of concentrated sulphuric acid at a temperature of 60 C. The reaction is performed for 60 min at a constant stir rate.

4.2.2. Stage 2: Esterification using alkali catalyst

In first stage itself, the concentration of FFA in the C.I oil is reduced to well below 0.5% by weight value, hence the second stage of transesterification is performed with alkali catalyst (potassium hydroxide). In this stage, a 6:1 M ratio of methanol to oil along with 1% by weight of concentrated potassium hydroxide at a temperature of 65 C is performed for 60 min duration at a constant stirring rate. During the transesterification reaction, the methanol gets trapped with the ester formed and this should be removed in order to increase the yield of CIME and this process is done by purification. In the purification process, the biodiesel is heated at 75 C for about 30 min duration to remove the trap. The following materials used for this research, Polanga and Thyme oil, nickel oxide Nano powder, cerium oxide Nano powder, and pure Diesel. The below table 4.1 shows the properties of Polanga oil and thyme oil and the table 4.2 shows transesterification results.

Table 4.1: The Values of Raw Polanga oil and thyme oil

S.NO	PROPERTIES	Polanga & Thyme oil
1	Density	0.910g/cc
2	kinematic viscosity	4.1cst
3	moisture content	0.013%
4	flash point	50°C
5	fire point	58°C
6	calorific value	36.279mj/kg

Table 4.2.2: Transesterification Report of Polanga oil and thyme oil

S.NO	PARAMETERS	RESULTS
1	Free fatty acid	0.33
2	Catalyst(NaOH) quantity	5grms
3	Oil to Methanol molar ratio	1:6
4	Temperature	60°C
5	Reaction time	90minutes
6	Yield	94.1%

4.3 PREPARATION OF NANOPARTICLE

Ultra sonicator is used to mix thoroughly the nanoparticles ZrO_2 with the biodiesel from Polanga and Thyme oil. The cerium oxide Nano particles of an average size of 20 nm were used for this investigation. This Ultra sonicator technique is used to disperse the Nano particles in the biodiesel mixture. 50 ppm cerium oxide and nickel oxide Nano particle was weighed by using electronic weighing machine with an accuracy of 0.02 mg. This Nano additive added biodiesel mixture were kept in the Ultra sonicator about 30 min and ensured that there is no deposits of power at the bottom of the beaker.

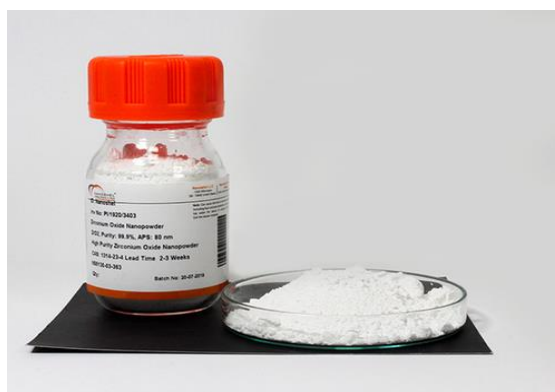


Fig:4.3 Zirconium oxide (ZrO_2)

4.3.1 Zirconium oxide (ZrO_2)

Zirconium oxide (ZrO_2), sometimes known as zirconia (not to be confused with zircon), is a white crystalline oxide of zirconium. Its most naturally occurring form, with a monoclinic crystalline structure, is the mineral baddeleyite. A dopant stabilized cubic structured zirconia, cubic zirconia, is synthesized in various colours for use as a gemstone and a diamond simulant.

Three phases are known monoclinic below 1170 °C, tetragonal between 1170 °C and 2370 °C, and cubic above 2370 °C. The trend is for higher symmetry at higher temperatures, as is usually the case. A small percentage of the oxides of calcium or yttrium stabilize in the cubic phase.

The very rare mineral tazheranite, $(\text{Zr,Ti,Ca})\text{O}_2$, is cubic. Unlike TiO_2 , which features six-coordinated titanium in all phases, monoclinic zirconia consists of seven-coordinated zirconium centres. This difference is attributed to the larger size of the zirconium atom relative to the titanium atom.

Zirconia is chemically unreactive. It is slowly attacked by concentrated hydrofluoric acid and sulfuric acid. When heated with carbon, it converts to zirconium carbide. When heated with carbon in the presence of chlorine, it converts to zirconium tetrachloride. This conversion is the basis for the purification of zirconium metal and is analogous to the Kroll process

Stabilized zirconia is used in oxygen sensors and fuel cell membranes because it has the ability to allow oxygen ions to move freely through the crystal structure at high temperatures. This high ionic conductivity (and a low electronic conductivity) makes it one of the most useful electroceramics. Zirconium dioxide is also used as the solid electrolyte in electrochromic devices.

4.3.2 Properties of Zirconium oxide (ZrO_2)

Table 4.3.2 Properties of Zirconium oxide (ZrO_2)

Compound Formula	ZrO_2
Molecular weight	123.218 g/mol
Appearance	White powder
Melting Point	2,715°C(4,919°F;2,988K)
Boiling Point	4,300 °C(7,770 °F;4,570 K)
Density	5.68g/cm ³
Solubility in H ₂ O	Soluble in HF, and hot H ₂ SO ₄
Exact Mass	121.895 g/mol
Monoisotopic Mass	121.894531 Da

4.4 EXPERIMENTAL SETUP

The test engine is a Kirloskar tv1 model single cylinder four-stroke water-cooled diesel engine developing 3.5 KW at a speed of 1500 rpm. This engine is directly coupled to a water cooled eddy-current dynamometer with a control system. "Enginesoft LV" Sonification Process. Collect the Polanga and thyme oil+nanoparticle in glass vessel in respective ratios immersed the vessel inside the GT SONIC device. In 40 degree Celsius 15 min done the sonification process, After the sonification process, samples can be ready to use for engine test.



Fig: 4.4 Ultrasonicator Device

4.5 BLENDS

S1=450ml diesel+50ml Polanga oil and thyme oil +30ppm ZrO₂

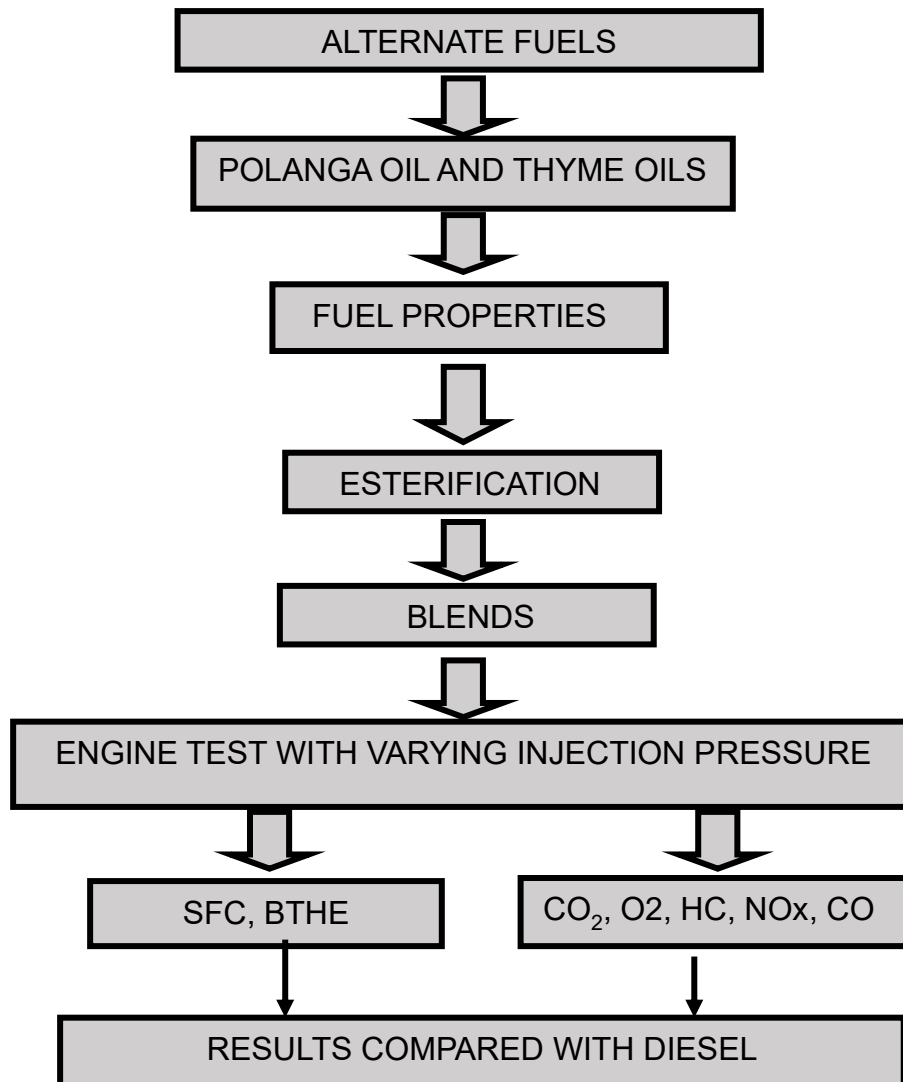
S2=400ml diesel+100ml Polanga oil and thyme oil +30ppm ZrO₂

S3=350ml diesel+150ml Polanga oil and thyme oil +30ppm ZrO₂

Table 4.5 properties of all sample

S.N O	PARAMETERS	S1	S2	S3
1	Density(g/cc)	0.818	0.845	0.834
2	Kinematic Viscosity@ 40°C (cSt)	1.32	1.44	1.39
3	Flash point by PMCC method (° C)	89	91	92
4	Fire point by PMCC method (° C)	102	104	105
5	Cloud point (° C)	1	1	2
6	Pour point (° C)	-15	-14	-15
7	Moisture content (%)	0.011	0.010	0.09
8	Calorific value (cal/g)	8815.556	8956.264	9062.324

4.6 METHODOLOGY



4.7. ENGINE SETUP

A single-cylinder has 4-stroke, direct injection Kirloskar TV1 diesel engine with a maximum rated output of 5.20 kW at 1500 rpm was utilized to obtain the set of experimental data required. The engine has a compression ratio of 17.5. The engine has a swept volume of 661.45 (cc), bore diameter of the engine is 87.50 mm and stroke length of 110.00 mm.

Injection pressure is 210 bar maintained constantly throughout the process the test engine is a Kirloskar tv1 model single cylinder four-stroke water-cooled diesel engine developing 3.5 KW at a speed of 1500 rpm. This engine is directly coupled to a water-cooled eddy-current dynamometer with a control system. “EnginesoftLV” an engine performance analysis software package is used for online performance evaluation. The exhaust gas temperature is measured by a K- type thermocouple in conjunction with a digital temperature indicator.



Fig:4.7 Engine setup

Table 4.7 constant speed diesel engine

Engine model	Kirloskar TV1
Power	5.20 kW
Speed	1500 rpm
Number of cylinders	Single Cylinder
Number of strokes	4 strokes
Cooling system	Water Cooled
Cylinder Bore	87.50(mm)
Stroke Length	110.00(mm)
Compression Ratio	17.50
Swept volume	661.45 (cc)
Injection pressure	210 Bar

4.8 AVL Gas Analyser



Fig: 4.8 AVL Gas Analyser

AVL gas analyser for measurement of co hc CO₂ O₂ and lambda. Pollution testing machines. Our customers are workshops, automobile engineering colleges its nits rta all engine manufacturer. It is portable type and used to measure concentration of SO₂, NO, CO, CO₂ and O₂ from stack or boiler emission gases, in which SO₂, NO, CO and CO₂ are measured by micro-flow infrared sensors and O₂ by electrochemical sensor, with optional gas temperature, pressure, velocity etc., calculating combustion efficiency, lambda, etc.

CHAPTER 5

RESULT AND DISCUSSION

5.1 BRAKE THERMAL EFFICIENCY (BTE)

Table 5.1: Brake thermal efficiency in %

BP (%)	BP (KW)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0.03	0%	2.45	3.39	1.49	0.97	0.54	3.92	2.85	1.83	1.5	2.43
0.99	25%	16.49	15.94	15.86	14.02	14.41	18.21	13.97	13.59	14.71	14.85
1.88	50%	22.75	27.38	23.5	22.49	21.82	25.14	25.05	21.18	24.14	22.14
2.78	75%	31.71	29.07	27.53	26.51	25.46	31.42	26.22	24.52	27.9	26.22
3.47	100%	32.59	32.1	32.38	35.55	28.82	35.57	29.06	31.71	33.27	30.22

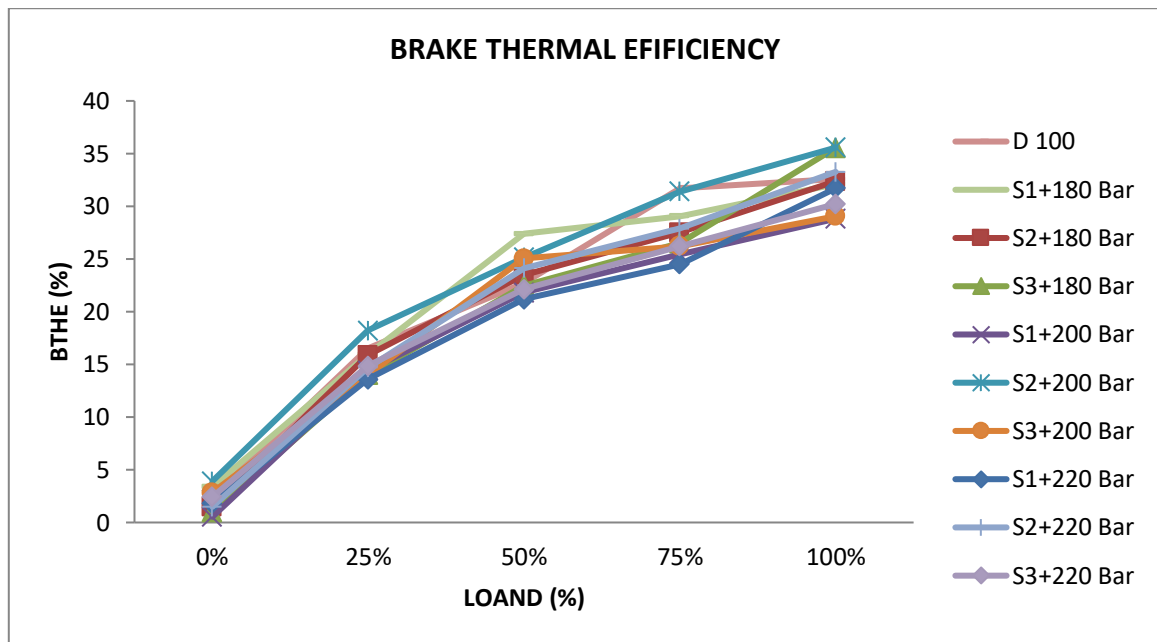


Fig 5.1: Brake thermal efficiency in %

The effect of varying brake power on brake thermal efficiency is shown in Fig. 5.1. Indicated power and engine friction are essential for calculating the Brake thermal efficiency of the engine. Efficiency is measured as a ratio of the measured performance to the performance of an ideal machine. Is given as an input to the device into an output force and movement. Hence, mechanical efficiency indicates in converting the indicated power to useful power.

Sample (S2) gives the maximum. Brake thermal efficiency for the maximum brake power. Sample (S3) also gives more brake thermal efficiency than Diesel at same brake power. But other two blends (S2 & S3) are had lower brake thermal efficiency than diesel.

5.2 SPECIFIC FUEL CONSUMPTION (SFC)

Table 5.2: Specific fuel consumption in Kg/kWh

BP (%)	BP (KW)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0.03	0%	2.48	2.62	3.97	4.15	2.42	3.05	3.11	4.87	5.94	3.65
0.99	25%	0.52	0.56	0.56	0.63	0.62	0.55	0.64	0.65	0.6	0.6
1.88	50%	0.38	0.32	0.38	0.4	0.41	0.42	0.35	0.42	0.37	0.4
2.78	75%	0.39	0.28	0.32	0.34	0.35	0.35	0.34	0.36	0.32	0.34
3.47	100%	0.2	0.31	0.13	0.29	0.31	0.31	0.31	0.28	0.25	0.26

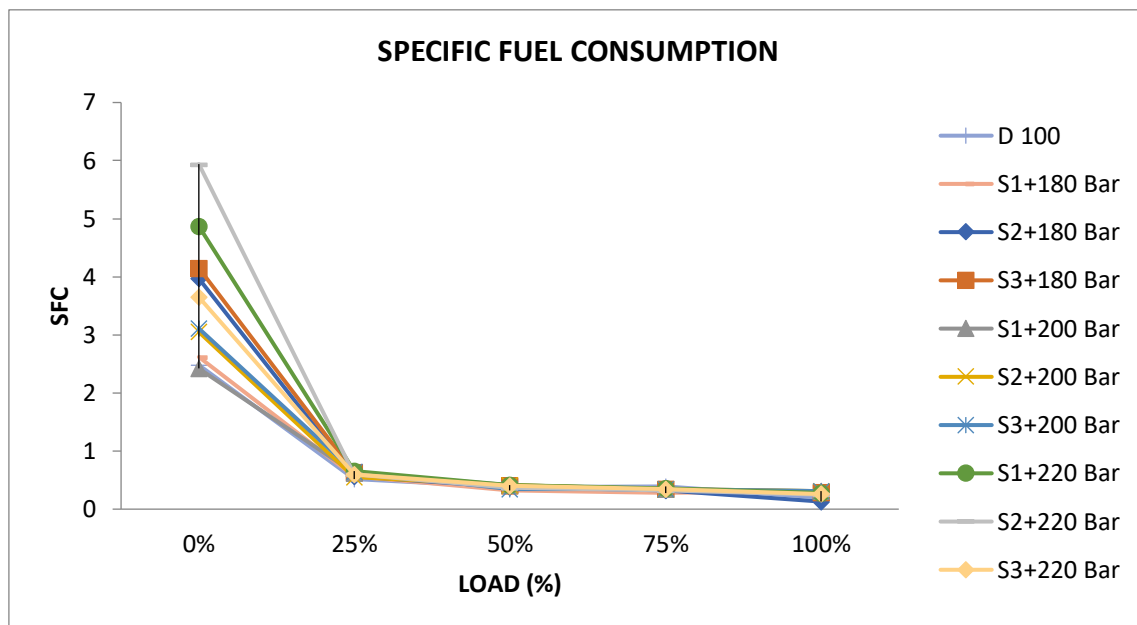


Fig 5.2: Specific fuel consumption in Kg/kWh

The above bar chart compares the specific fuel consumption of Polanga and Thyme oil and biodiesel with pure diesel at different break powers. There is no significant change in specific fuel consumption of both Polanga and Thyme oil bio diesels and all the break powers. So, we can conclude from the bar chart that both Polanga and Thyme oil with biodiesels and pure diesel has almost same specific fuel consumption.

5.3 NOx EMISSION

Table 5.3: NOx Emission in ppm

BP (%)	BP (KW)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0.03	0%	138	117	170	260	75	62	78	90	85	189
0.99	25%	235	219	289	359	125	125	139	176	172	255
1.88	50%	432	323	454	545	203	228	217	272	377	481
2.78	75%	603	664	766	833	354	466	398	444	462	596
3.47	100%	1151	887	911	1011	800	947	834	927	1041	1055

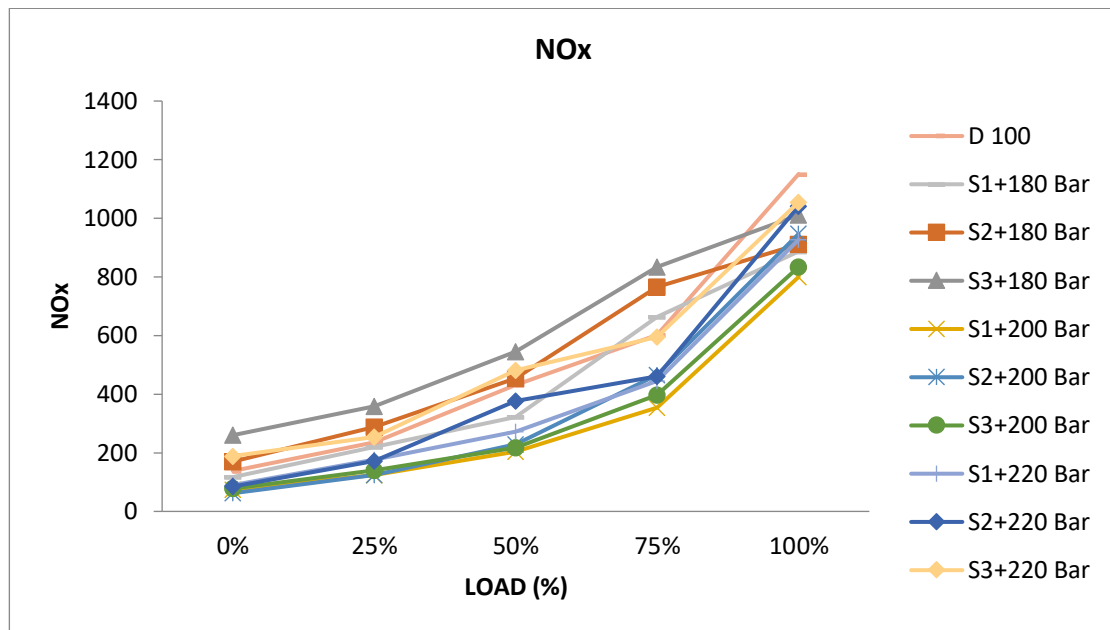


Fig 5.3: NOx Emission in ppm

The above bar chart compares NOx emission of both and Polanga and Thyme oil biofuel with pure diesel at all break powers. A30 and C30 produces NOx lesser Than D100. A10 produces higher NOx more than 1100 ppm. C10 A20 and produces NOx very similar to D100 at 3.1kw break power.

5.4 CO₂ EMISSION

Table 5.4 CO₂ Emission in ppm

BP (Load)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0%	2.09	1.02	0.94	1.14	0.91	0.87	0.9	0.87	1.18	1.47
25%	2.73	1.54	1.62	1.74	1.2	1.23	1.55	1.86	1.63	2.06
50%	3.61	1.87	2.1	2.28	1.25	1.94	1.6	2.12	2.28	2.69
75%	3.69	1.98	2.37	2.38	1.58	2.34	2	2.55	2.24	2.84
100%	5.32	2.83	2.58	2.52	1.92	2.53	2.98	2.64	2.82	3.21

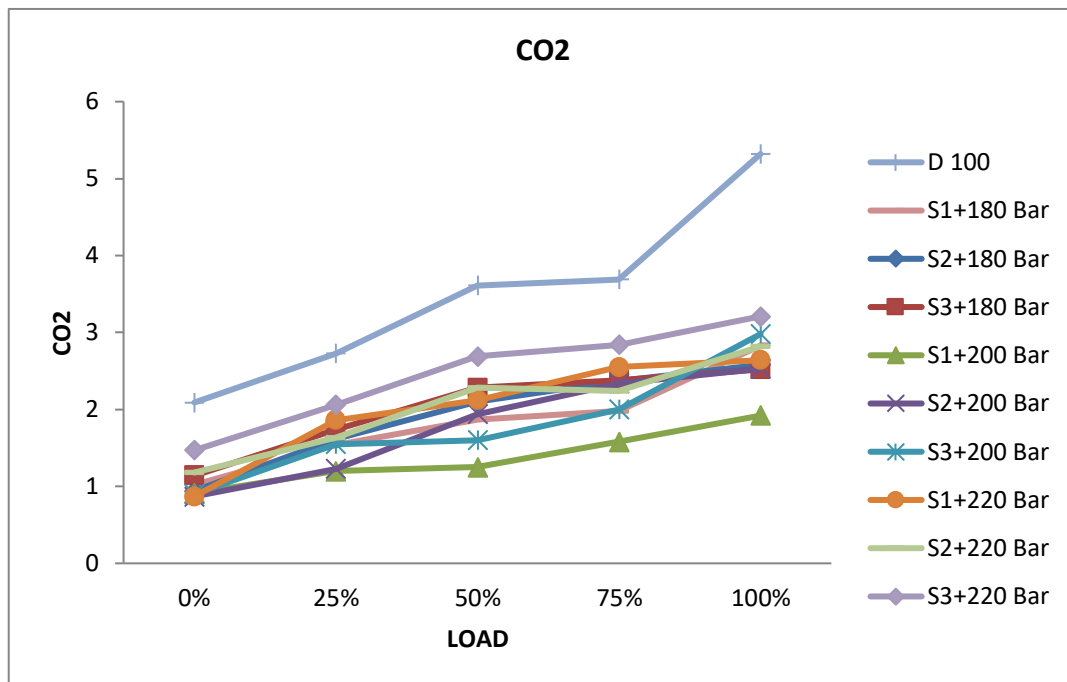


Fig 5.4: CO₂ Emission in ppm

Above bar chart compares CO₂ emission of both biodiesel blends with Polanga and Thyme oil biodiesel blends. CO₂ emission is one of the dangerous gas released during combustion, so it is important to reduce the CO emission. Our experiment shows that S1, S2, S3, & S4 produces less CO emission than D100 but C10 and A30 produces little high emission than D100 at 3.10kw break power.

5.5 HC EMISSION

Table 5.5 HC Emission in %

	BP (KW)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0.03	0%	53	55	57	58	53	54	55	56	58	60
0.99	25%	53	56	58	59	53	55	56	57	60	60
1.88	50%	53	58	60	62	54	58	58	58	61	62
2.78	75%	54	59	61	63	55	58	60	59	65	65
3.47	100%	67	62	63	65	56	59	62	64	68	69

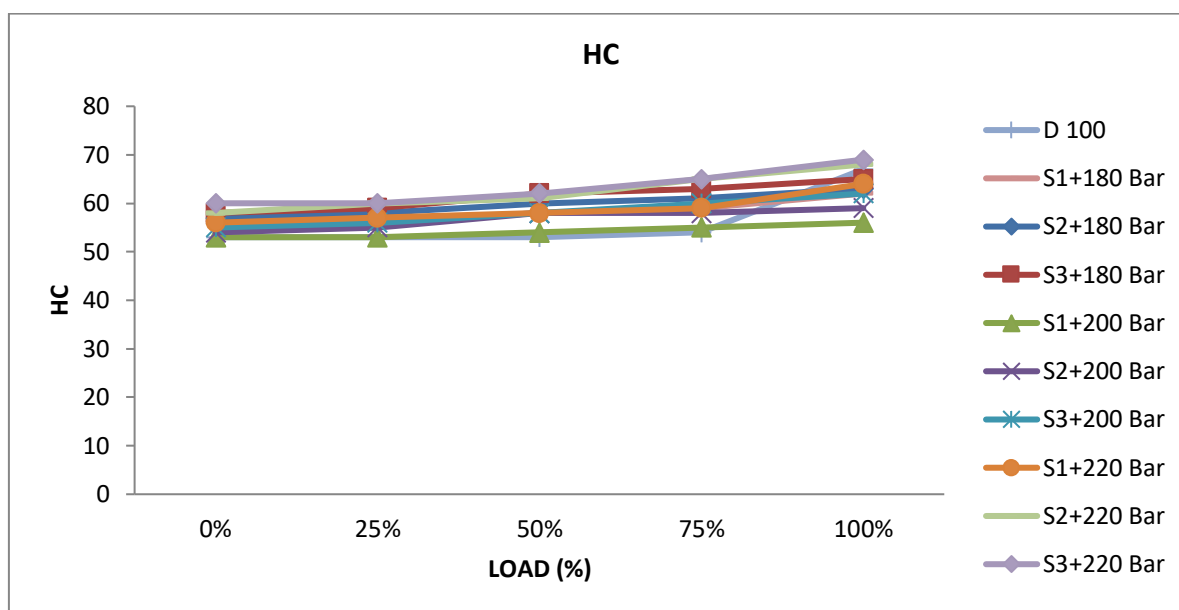


Fig 5.5: HC Emission in ppm

This chart compares the emission of HC of Polanga and Thyme oil biodiesel blends with D100. Unburnt fuel from the engine comes out as an emission which should be reduced to save the environment. In and Polanga and Thyme oil biodiesels there is no significant change in HC emission. S2 and S3 produces little higher emission than D100. S2 produces higher HC than all the blends.

5.6 CO EMISSION

Table 5.6 Emission in CO %

	BP (KW)	D 100	S1+180 Bar	S2+180 Bar	S3+180 Bar	S1+200 Bar	S2+200 Bar	S3+200 Bar	S1+220 Bar	S2+220 Bar	S3+220 Bar
0.03	0%	0.073	0.078	0.076	0.07	0.072	0.082	0.084	0.076	0.093	0.077
0.99	25%	0.072	0.075	0.075	0.068	0.065	0.079	0.08	0.068	0.082	0.076
1.88	50%	0.07	0.073	0.073	0.065	0.062	0.075	0.075	0.063	0.074	0.07
2.78	75%	0.067	0.07	0.07	0.062	0.054	0.069	0.069	0.061	0.065	0.068
3.47	100%	0.058	0.069	0.068	0.053	0.049	0.061	0.061	0.052	0.061	0.062

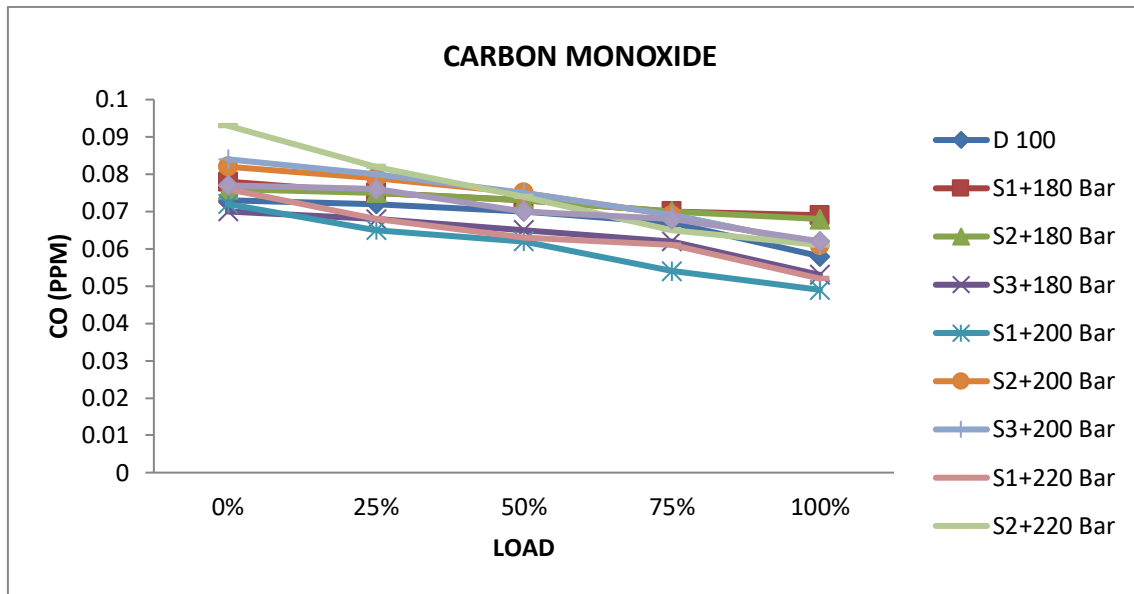


Fig 5.6: CO Emission in %

From fig 5.6, the average of CO% in all the size blends under varying brake power is comparatively lower than diesel, Blend 1(BL1) 4.67% lower than diesel, Blend 2(BL2) 4.13% is lower than diesel and Blend 3(BL3) 4.62% lower than that of diesel and Blend 4 (BL4) 4.25% is also lower than diesel. This is due to the oxygen contents in the biodiesel which makes easy burning at higher temperature in the cylinder.

CHAPTER 6

SUMMARY AND CONCLUSIONS

From this experiment it is seen that biodiesel is going to be the natural choice for our future transport fuel. The foregoing combination of experience and reasoning it is possible to distil some conclusions about biodiesel as an automotive fuel particularly in a developing country like India. The facts have been following established through the present work.

For Better BTE, BTE of D100 compared with S1, S2, S3, S4, S5 and S6, Finally C10 produces 5% more BTE than D100. Hence has more BTE than Polanga and Thyme oil and D100

For Better Specific fuel consumption, the results show that almost all the sample having same specific fuel consumption. There is no significant changes at all break powers

For Lower HC, the result shows that there is no significant change in HC emission at all break powers.

For lower CO, D100 is compared with Biodiesel blend samples. The result shows that S2 & S3 reduces CO emission compared to D100 and other sample blends.

For lower NO_x, bio diesel produces lower NO_x than Polanga and Thyme oil. But when compared with D100 S3 produces less NO_x at higher break power.

CHAPTER 7

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EXPERIMENTAL INVESTIGATIONS ON 4-STROKE DI DIESEL ENGINE USING METHYL ESTERS OF POLANGA OIL AND THYME OILS AT DIFFERENT INJECTION TIMINGS, INJECTION PRESSURES.
Submitted in partial fulfillment of the requirements For the award of Bachelor of Engineering degree in Mechanical Engineering By HAMILTON V DE PAUL (37150070) VENKADESH PRASAD G (37150210) / 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 March 2021 / DEPARTMENT OF MECHANICAL ENGINEERING BONAFIDE CERTIFICATE This is to certify that this Project Report is the bonafide work of G.

VENKADESH PRASAD (37150210), HAMILTON V DE PAUL (37150070) who carried out the project entitled "Experimental investigations on 4-stroke di diesel engine using methyl esters of polanga oil and thyme oils at different injection timings, injection pressures". Under our supervision from September 2019 to April 2020. Internal Guide Mr. J.SENTHILKUMAR Head of the Department Dr.G. ARUNKUMAR, M.E., Ph.D., / Submitted for Viva voice Examination held on _____ Internal Examiner External Examiner DECLARATION We HAMILTON V DE PAUL (37150070), G.VENKADESH PRASAD (37150210) hereby declare that the project report entitled "Experimental Investigations on 4-stroke DI Diesel Engine using Methyl Esters of Polanga oil and Thyme oils at Different injection timings, Injection Pressures."

Done by me under the guidance of Mr. J.SENTHILKUMAR is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree In Mechanical Engineering. 1. DATE: 2.

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