

EFFECTS OF BIOGLYCEROL BASED FUEL ADDITIVES ON DIESEL ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS WITH DI-TERTIARY-BUTYL ETHER

**Submitted for partial fulfilment of the requirements for the award of
Bachelor of Technology in
Mechanical Engineering**

By

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

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March 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project report is the bonafide work of **GOWSIK SARAN. R.S (37150063)** and **KIRANPRADEEP. N (37150099)** who carried out the project entitled on “**EFFECTS OF BIOGLYCEROL BASED FUEL ADDITIVES ON DIESEL ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS WITH DI-TERTIARY-BUTYL ETHER**” under our supervision from September 2020 to March 2021.

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DECLARATION

We **GOWSIK SARAN. R.S (37150063)** and **KIRANPRADEEP.N (37150099)** hereby declare that the Project report entitled **“EFFECTS OF BIOGLYCEROL BASED FUEL ADDITIVES ON DIESEL ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS WITH DI-TERTIARY-BUTYL ETHER”** done under the guidance of **Dr. GANESAN , Department of Mechanical Engineering** is submitted in partial fulfilment of the requirements for the award of **Bachelor of Technology in Mechanical Engineering.**

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SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We would like to express our gratitude to the Board of Management of the **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their support in completing this project successfully.

First and foremost, we want to thank God for keeping us safe in body and mind so that we could successfully complete the project.

Our sincere and heartfelt appreciation to **Dr. GANESAN M.E.,Ph.D.**, Department of Mechanical Engineering, for her invaluable guidance, advice, and relentless motivation, which paved the way for the project's effective completion.

We would like to express our heartfelt gratitude to **Dr. ARUN KUMAR**, Head of Department. We would like to express our gratitude to all teachers and members for providing us with the requisite resources and information at the appropriate times during our project's progressive reviews.

Last but not least, we want to express our sincere gratitude to our loving parents, family members, and friends, who have all helped me finish my project and earn my degree.

ABSTRACT

Due to the awareness of adverse effects of conventional fuels to environment and the frequent rise in crude oil's price, the need for sustainable and environment friendly alternate source of energy has gained importance in recent years. Biodiesel is proved to be the best replacement for diesel because of its unique properties like significant reduction in greenhouse gas emissions, non-sulfur emissions, non-particulate matter pollutants, low toxicity and biodegradability. This paper reviews the pretreatment step, the physical and chemical properties of waste cooking oil, Esterification, Transesterification and production of Biodiesel from waste cooking oil by various methods and catalysts reported so far. The factors affecting the process parameters reported are studied and the point of interest focuses on their Alcohol to oil ratio, Reaction temperature, Catalyst both qualitative and quantitative scope. The optimum condition is investigated and the exhaust emissions of Biodiesel and Petroleum diesel are compared.

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LIST OF ABBREVIATIONS

BTE	-	Brake Thermal Efficiency
CARB	-	California Air Resources Board
CFPP	-	Cold Filter Plugging Point
CN	-	Cetane Number
CO	-	Carbon Monoxide
CO ₂	-	Carbon Dioxide
CP	-	Cloud Point
DC	-	Distillation Curve
DPGE	-	Di-Propyl Glycerol Ethers
DTBG	-	Di-Tert-Butylglycerols
FID	-	Flame Ionization Detector
FP	-	Flash Point
FT-IR	-	Fourier Transform Infrared
IB	-	Isobutene
ISU	-	International System of Units
LCA	-	Life Cycle Assessment
LTFT	-	Low Temperature Flow Test
NO _x	-	Nitrous Oxide
OEM	-	Original Equipment Manufacturer
ON	-	Octane Numbers
PP	-	Pour Point
SCR	-	Selective Catalytic Reduction
SFC	-	Specific Fuel Consumption
SO ₂	-	Sulfur Dioxide
TBA	-	Tert-Butyl Alcohol
TPGEs	-	Tri-Propyl Glycerol Ethers
TTBG	-	Tri-Tert-Butylglycerols
XRD	-	X-ray Diffraction

CHAPTER 1

INTRODUCTION

Biodiesel is a liquid biofuel made from vegetable oils or animal fats and an alcohol that can be used alone or in combination with diesel engines. Diesel oil is added to the mix. Biodiesel is described as a mixture of long-chain monoalkylic esters from plants. Fatty acids derived from renewable resources that will be used in diesel engines. Blends with diesel fuel are indicated as “Bx”, where “x” is the percentage of biodiesel in the blend. For instance, “B5” indicates a blend with 5% biodiesel and 95% diesel fuel; in consequence, B100 indicates pure biodiesel.

1.1 ADVANTAGES OF THE USE OF BIODIESEL

- Renewable fuel, obtained from vegetable oils or animal fats.
- Low toxicity, in comparison with diesel fuel.
- Degrades more rapidly than diesel fuel, minimizing the environmental consequences of biofuel spills
- Lower emissions of contaminants: carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes.
- Lower health risk, due to reduced emissions of carcinogenic substances.
- No sulfur dioxide (SO₂) emissions.
- Higher flash point (100°C minimum).
- May be blended with diesel fuel at any proportion; both fuels may be mixed during the fuel supply to vehicles.

- Excellent properties as a lubricant.
- It is the only alternative fuel that can be used in a conventional diesel engine, without modifications.
- Used cooking oils and fat residues from meat processing may be used as raw materials.

1.2 DISADVANTAGES OF THE USE OF BIODIESEL

- Due to the lower calorific value of biodiesel, there is a slight increase in fuel consumption.
- Nitrous oxide (NO_x) emissions are slightly higher than diesel fuel.
- It has a higher freezing point than petrol. This may be uncomfortable in the winter.
- Since it is less reliable than gasoline, long-term storage (more than six months) is not recommended. It is not recommended to use biodiesel for more than a few months.
- When used in pure form, it can degrade plastic and natural rubber gaskets and hoses.

1.3 RAW MATERIALS FOR BIODIESEL PRODUCTION

Vegetable oils, animal fats, and short-chain alcohols are the raw materials used to make biodiesel. Rapeseed (primarily in European Union countries), soybean (Argentina and the United States of America), palm (Asian and Central American countries), and sunflower are the most commonly used oils for biodiesel production worldwide. Other oils, such as peanut, linseed, safflower, used vegetable oils, and animal fats, are also used. The most commonly used alcohol is methanol.

Since cost is a major factor in biodiesel production and distribution (due to the oil prices), non-edible vegetable oils have been studied for several years with promising results.

Aside from the lower cost, another undeniable benefit of non-edible oils for biodiesel production is that no food is wasted in the process.

These and other factors have contributed to the development of biodiesel on a medium and large scale. Castor oil, tung, cotton, and other non-edible oils were used in trials in many countries. Since they are solid, they require preliminary treatment; additionally, highly acidic grease from Cattle, pork, poultry, and fish are all acceptable options.

Due to their high oil yield, microalgae tend to be a very important option for potential biodiesel production; however, it should be noted that only a few organisms are suitable for biofuel production.

1.4 PHYSICO-CHEMICAL PROPERTIES OF DIESEL FUELS

Since automobiles and their engines are designed to work in a variety of environments, achieving the desired performance and reliability is dependent on both technical factors related to their manufacturing and the nature of the fuels used. As a result, the physico-chemical properties of the fuels must be presented. They have an impact on the performance of the engines. Furthermore, given the large number of fuels produced by combining various combustibles. The study of their physico-chemical properties becomes extremely important.

1.4.1 Viscosity

Viscosity is a measure of resistance to liquid flow caused by internal friction of one component of a fluid flowing over another under the force of gravity, according to the international norm. This is an important property since it influences how fuel behaves. Since ambient temperature has an effect on viscosity, precautions must be taken to prevent the engine's performance from deteriorating, for example, due to the higher viscosity, attempting to start the engine at very low ambient temperatures. The engine may have trouble starting due to a lack of fuel.

Larger droplet volumes, poorer fuel atomization and vaporisation, High viscosity can also lower fuel flow rates, resulting in insufficient fuel delivery. A source

of energy Pump distortion may also be caused by a very high viscosity. Finally, High fuel viscosity results in poorer overall combustion, higher emissions, and higher costs. Dilution of oil.

1.4.2 *Depending on the measurement method, there are Two Types of viscosity*

Dynamic or absolute (η) viscosity is expressed in ISU (International System of Units) in $[\text{Ns} / \text{m}^2]$. In the CGS system (centimeter, gram, second), dynamic viscosity is expressed in $\text{P} = \text{Poise}$.

1.4.3 *Density*

The density, or more precisely, the volumetric mass density of a substance is its mass per unit volume. Fuel density is another key property that affects engine performance. Because fuel is metered by volume, not by mass, a greater or lesser mass of fuel is injected depending on its density. Thus, the air-fuel ratio and energy content within the combustion chamber are influenced by fuel density. Density increases when the ambient temperature lowers; therefore, like viscosity, it affects the engine cold starting performance. The measurement unit of density is kg/m^3 .

1.4.4 *Cetane Number*

Cetane Number (CN) is the main indication of the auto-ignition and combustion quality characteristics of the fuel used in a diesel engine. It affects cold startability, combustion stability and noise. A higher CN generally decreases engine cranking time (the time before the engine reaches by decreasing the ignition delay).

1.4.5 *Evaporation Characteristics*

Evaporation characteristics influence the spray structure and affect the preparation of air–fuel mixture under different engine load conditions. The volatility characteristics are described by using the vapor pressure and distillation curve which are affected by intermolecular interactions. 11 The Distillation Curve (DC)

indicates the amount of fuel that boils off at a given temperature. The curve can be divided into three parts:

- (1) as in the beginning, only the light fractions of the fuel boil, the first region can be called the light end; it affects start ability and is usually characterized by the temperature at which 10% of the fuel has boiled (T10);
- (2) the region around the 50% evaporated point, characterized by the T50;
- (3) the heavy end (i.e., boiling of the heaviest fuel fractions), which is usually characterized by the T90 or T95 and has been the most thoroughly studied with respect to its effect on tailpipe emissions

1.4.6 *Flash Point Closed Cup*

The minimum temperature at which the fuel can ignite (flash) when an ignition source is applied under defined conditions is known as the flash point (FP). It is used to classify transportation fuels. Minimum flash point temperatures are needed, as well as storage according to danger level. For the proper handling and protection of the fuel. The flash point is inversely proportional to the temperature.

1.4.7 *Cold Flow Characteristics*

One of the most fundamental quality criteria for compression ignition engine fuels is the cold flow characteristics, which are primarily dictated by:

- (1) fuel distillation range, mainly the light-end volatility;
- (2) hydrocarbon composition: content of paraffins, naphthene, aromatics;
- (3) use of cold flow additives.

The mechanism of cold flow properties is: During low-temperature engine action, fuel gelling occurs, resulting in crystallisation of the liquid molecules. The molecules of the liquid must produce heat in order for crystallisation to occur. The

strong intermolecular force of interaction provides ample thermodynamic force. This is a good example. When the temperature of a liquid is reduced to a certain point, thermodynamic force is produced. Its thawing stage Fuel crystallisation will result in “fuel starvation” and loss of operability. Solidified material clogs fuel lines, the fuel pump, filters, and injectors, causing problems.

Three fuel parameters specify the low-temperature operability of diesel engines: Cloud Point (CP), Cold Filter Plugging Point (CFPP), and Pour Point (PP).

When the liquid fuel is cooled, the following parameters can be defined: The lowest temperature at which a given volume of diesel engine fuel passes through a standardised filtration system in a given amount of time is known as the CFPP. The Low Temperature Flow Test (LTFT) was created exclusively for the United States and Canada to predict how. Low-temperature performance is possible with diesel engine fuels. The LTFT stands for “slow cooling test”. PP is the lowest temperature at which the fuel can stop burning, and it is more extreme than CFPP.to go with the breeze.

The cold flow properties of diesel engine fuel must be defined according to the seasonal and climatic conditions in the area where the fuel would be used, The temperature at which a clear liquid product becomes cloudy is defined as follows: CP is the temperature at which a clear liquid product becomes cloudy, i.e. when stable particles (alkane crystals and microcrystals of ice).

1.4.8 Cold Flow Limits

The diesel fuel cold flow performance can be specified by Cloud Point, by CFPP (with maximum delta between CFPP and Cloud Point), or by LTFT.

- a) If Cloud Point (only) or LTFT is used, the maximum allowed temperature should be set no higher than the lowest expected ambient temperature.
- b) If CFPP is used to predict cold flow, the maximum allowed CFPP temperature should be set equal to, or lower than, the lowest

expected ambient temperature. In this case, the Cloud Point should be no more than 10°C above the CFPP specified.

1.4.9 Water Content

The fuel should be clear in appearance and free of water, which can plug fuel filters at negative temperatures, leading to engine fuel starvation. Water accelerates oxidation, increases corrosivity and promotes microbial growth. The unit for water content could be [mg/kg].

1.5 GLYCEROL

Glycerol also called **glycerine** or **glycerin** is a simple polyol compound. It is a colorless, odorless, viscous liquid that is sweet-tasting and non-toxic. The glycerol backbone is found in those lipids known as glycerides. Due to having antimicrobial and antiviral properties it is widely used in FDA approved wound and burn treatments. It can also be used as an effective marker to measure liver disease. It is also widely used as a sweetener in the food industry and as a humectant in pharmaceutical formulations. Owing to the presence of three hydroxyl groups, glycerol is miscible with water and is hygroscopic in nature.

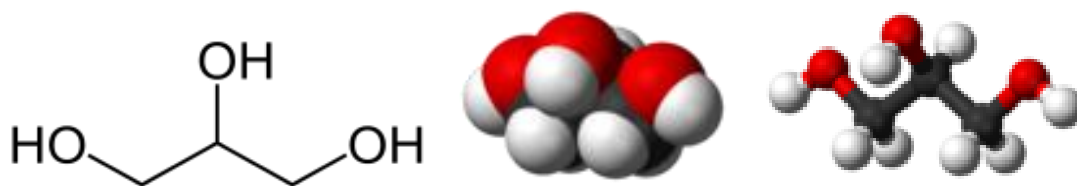


Figure 1.1 Glycerol

1.5.1 *Properties of Glycerol*

Table 1.1 Properties of Glycerol

Chemical formula	C ₃ H ₈ O ₃
Molar mass	92.094 g·mol ⁻¹
Appearance	Colorless hygroscopic liquid
Odor	Odorless
Density	1.261 g/cm ³
Melting point	17.8 °C (64.0 °F; 290.9 K)
Boiling point	290 °C (554 °F; 563 K)
Solubility in water	Miscible
Log P	-2.32
Vapor pressure	0.003 mmHg (50 °C)
Magnetic susceptibility (χ)	-57.06·10 ⁻⁶ cm ³ /mol
Refractive index (n_D)	1.4746
Viscosity	1.412 Pa·s

1.5.2 *Applications of Glycerol*

Owing to its antiviral and antimicrobial properties, glycerol can be employed for the treatment of wounds and certain types of burns. It has also been suggested that the treatment of wounds with an 86% solution of glycerol may help reduce the inflammation in the wounded area. However, it is important to note that glycerol must not be used for the treatment of third degree burns. It can also be noted that glycerol is used as a component in the preparation of many medical and pharmaceutical products. Furthermore, this compound is also employed in the preparation of many personal care products (owing to its antimicrobial nature) such as shaving cream, toothpastes, mouthwashes, soaps, skin care products, and hair care products.

This compound is also used in cough syrups, allergen immunotherapies, and elixirs. Another important application of glycerol is in blood banks, where the compound is employed for the preservation of red blood cells (often abbreviated to RBCs) before they are frozen for storage. This compound is also the core component of glycerin soap.

1.6 MATERIALS AND METHODS

Materials

Waste cooking oil, Di-tertiary-butyl-ether (glycerol), Diesel.

1.6.1 Waste Cooking Oil

Waste cooking oil is the end-product of frying foods using **cooking oil** which contains plant or animal fats that have been processed. ... The original source of **cooking oil** is plant-based lipids such as coconut **oil**, palm **oil**, olive **oil**, and canola **oil**, or lipid-based animals, such as butter and ghee. Edible fat mixed in kitchen waste and oily waste water directly discharged into the sewer. China is the large producer of waste cooking oil, with 500 million tons of waste cooking oil produced each year in the catering industry of large and medium cities. If the waste is improperly handled, it will pollute the cities, as well as flow back to the dining tables in case of weak government supervisory, profit-driven practices and lack of rapid test. According to the statistics, China's waste cooking oil flowing back to the dining table amounts to 200–300 million tons, which poses a great health hazard to consumers. Therefore disposal and reutilization of waste cooking oil is a long-term alarming problem in China. As a solution of this problem, converting waste cooking oil into biofuel is a three-win alternative, dealing simultaneously with food security, pollution, and energy security. The world energy producing and consuming countries such as US, Japan, Brazil and Germany have enacted supporting policies. Chinese government also gives great importance to the development of waste cooking oil disposal and biofuel. To process waste oil, China has promulgated Regulations on the Waste Cooking Oil Management for the Food Production and Business Operation Entities (2002), Emergency Notification of Preventing Entry of Waste Cooking Oil Entering Food & Beverage Services (2010), Opinions on Strengthening

Management of Kitchen Waste and Drainage Oil (2010), successively. As for the exploitation of biofuel, China launched the Tenth Five-year Programme for National Key Technology Research and Development in 2004. In January 2006, Renewable Energy Law was implemented, which was designed to encourage the production and use of bio-liquid fuel. In the same year in September, the Ministry of Finance, National Development and Reform Commission, the Ministry of Agriculture, the State Administration of Taxation, The State Forestry Bureau jointly issued Proposals for Implementation of Tax Support Policy on Development of Bioenergy and Biochemical Industry, providing biofuel with financial and tax benefits. Nevertheless, China still lags behind of developed countries in the waste oil refining biofuel. In the practice of biofuel enterprises, many problems such as shortage of raw material and sluggish sales need to be solved urgently. Meaningful work, sorting out and assessing relative policies systematically are the efficient way to solve this problem. Also, this is the logical starting point of the paper.

1.6.2 *Physical and Chemical Properties of Waste Cooking Oil*

Acid value (mg KOH/g)		2.04 ± 0.03
Saponification value (mg KOH/g)		204.77 ± 1.40
Molecular weight (g/mol)		822.03 ± 5.63
FFA (%)		1.02 ± 0.02
Higher Heating Value (MJ/kg)		39.96 ± 0.04
Density (g/cm ³)	at 20 ⁰ C	0.91567 ± 0.00003
	at 40 ⁰ C	0.90195 ± 0.00004
	at 60 ⁰ C	0.88844 ± 0.00003
Kinematic viscosity (mm ² /s)	at 20 ⁰ C	124.00 ± 0.01
	at 40 ⁰ C	51.04 ± 0.03
	at 60 ⁰ C	26.28 ± 0.02
Peroxide value	(meq/kg)	7.13 ± 0.12
	(mg/g)	57.07 ± 0.92
Oxidative Stability (h)		18.71 ± 0.04

Iodine value(g I ₂ /100 g)	57.70 ± 0.53
Moisture content (wt%)	0.12 ± 0.00
Flash point (°C)	309 ± 1
Glycerides (wt %)	
Monoglycerides	0.04
Diglycerides	3.47 ± 0.15
Triglycerides	96.43 ± 0.35
Fatty acid composition (wt%)	
Myristic acid, C14:0	0.98 ± 0.01
Palmitic acid, C16:0	39.02 ± 0.35
Stearic acid, C18:0	4.52 ± 0.28
Oleic acid, C18:1	44.57 ± 0.62

1.6.3 *Transesterification Reaction of Waste Cooking Oil*

50 ml of waste cooking oil and a pre-determined amount of catalyst and methanol were charged into a 300 ml stainless steel batch reactor equipped with thermocouple and magnetic stirrer SS.

The reactor was then pressurized to 10 bars to ensure that all reactants remain in liquid phase for the entire duration of reaction. The reactants were stirred at 350 rpm in order to maintain uniform temperature and suspension. The reactor temperature was controlled by a heater with a programmable PID temperature controller. After running the reaction for a desired duration, the reactor was cooled to room temperature. After cooling, the product was discharged out and filtered using filter paper to separate the solid catalyst from the mixture of FAME-glycerol.

1.6.4 *Method of Analysis*

The identity and relative composition of fatty acids present in the methyl ester product were analyzed by PerkinElmer Clarus 500 gas chromatograph equipped with flame ionization detector (FID) and Nukol™ column (15 m 0.53 mm 0.5 mm). Helium was used as carrier gas. Oven temperature was held at 110 8C

(0.5 min) and was then heated at a rate of 10 °C/min to 220 °C (8 min). The temperature of injector and detector was set at 220 and 250 °C, respectively.

1.6.5 Catalyst Characterization

X-ray diffraction (XRD) analysis was carried out using Siemens D5000 X-ray diffractometer with Cu K α radiation operated at 40 kV and 40 mA in the range of diffraction $2\theta = 20\text{--}100^\circ$ at a sweep rate of 0.048/s. Fourier transform infrared (FT-IR) spectroscopy analysis was carried out using PerkinElmer FT-IR 2000 spectrometer over the frequency range of 4000–400 cm⁻¹. Brunauer-Emmer-Teller (BET) surface area, average pore width and pore volume analysis was carried out using Quantachrome Autosorb-1 surface analyzer, in which the catalyst was pre-treated initially at 200 °C for 1 h to remove any adsorbed species on the surface. Temperature-programmed desorption of ammonia (NH₃-TPD) was performed using Autochem II 2920, in which the catalyst was pre-treated at 200 °C for 1 h. The NH₃-TPD was then carried out at 300 °C for different temperature ramp rates, ranging from 10 to 20 °C/min.

1.7 DI-TERTIARY-BUTYL ETHER

Di-tertiary-butyl ether is a tertiary ether that is used as a solvent

IUPAC NAME : 2-*tert*-Butoxy-2-methylpropane

tert-butyl methyl ether can be prepared by the reaction of potassium **tert**-butoxide and bromomethane. A colorless liquid with a distinctive anesthetic-like odor. Vapors are heavier than air and narcotic. Boiling point 131°F.

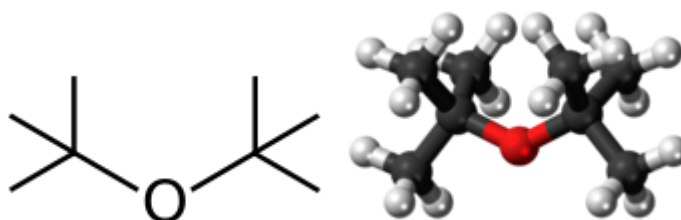


Figure 1.2 DI-Tertiary-Butyl Ether

1.7.1 Physical and Chemical Properties of DI-Tertiary-Butyl Ether

Table 2 Physical and Chemical Properties of DI-Tertiary-Butyl Ether

Properties	
Chemical formula	C ₈ H ₁₈ O
Molar mass	130.231 g·mol ⁻¹
Appearance	colorless liquid
Density	0.7658 g/cm ³
Melting point	-61 °C (-78 °F; 212 K)
Boiling point	107.2 °C (225.0 °F; 380.3 K)
Vapor pressure	3730 Pa (at 22 °C)
Thermochemistry	
Heat capacity (C)	276.1 J·mol ⁻¹ ·K ⁻¹
Std enthalpy of formation ($\Delta_f H^\ominus_{298}$)	-399.6 kJ·mol ⁻¹
Hazards	
Flash point	-3 °C (27 °F; 270 K)
Autoignition temperature	365 °C (689 °F; 638 K)

CHAPTER 2

LITERATURE SURVEY

S. D. Thorbole has conducted research on Biodiesel is a fatty acid methyl or ethyl ester derived from a variety of sources including edible oil, non-edible oil, animal fat, and algae. Calorific value, density, viscosity, cetane number, flash point, cloud point, pour point, distillation range, carbon residue, sulphur content, ash content, copper corrosion, and so on are some of the physicochemical properties of Biodiesel. Generic alteration, modifying the fatty acid composition, and adding additives are all options for enhancing biodiesel fuel properties. Oxygenated additives, metallic and nonmetallic additives, water, anti-oxidants, and polymeric related additives are all examples of additives that can be used to improve biodiesel properties. This paper aims to describe the efforts of various researchers to improve biodiesel fuel properties using various additives, as well as their effect on CI engine performance.

Norhasyim iRahmat has conducted research on Glycerol that emerges as a valuable chemical that can be transformed into high-value goods. Glycerol has proven to have enormous potential to be converted, thus superseding traditional petroleum-derived fuel additives in the face of biorefinery industries and high demand for renewable sources. This review paper discusses various forms of oxygenated biocomponents as well as rigorous studies of glycerol transformation into fuel additives. Ethylation, acetylation, and acetalation processes are studied in depth, with complex behaviours in each reaction mechanism.

Andrey I. Nekhaev has conducted research on Glycerol in a fixed-bed flow reactor, glycerol alkylation with tert-butyl alcohol and ketalisation of glycerol 1-mono-tert-butyl ether with acetone, as well as the combined ketalisation–alkylation process, were investigated. A continuous, one-step method for the quantitative conversion of glycerol into a mixture of ethers has been demonstrated over a zeolite

BEA catalyst under mild conditions (atmospheric pressure and temperatures of 40–70 °C). The effects of glycerol ether additives on the antiwear properties of low-viscosity base oil were also examined.

Tungasmita Duangamol Nuntasri has conducted research on Mono-propyl glycerol ethers (MPGEs), 1,3-di- and 1,2-di-propyl glycerol ethers (DPGEs), and tri-propyl glycerol ethers (TPGEs) were formed by etherification of glycerol with propylene over acidic heterogeneous catalysts, Amberlyst-15, S100, and S200 resins (TPGE). Only TPGE was generated when glycerol was propylated over Amberlyst-15. 1-mono-, 2-mono-, 1,2-di-, and 1,3-di-butyl glycerol ethers were formed by etherifying glycerol with 1-butene over Amberlyst-15 and S200 resins (1-MBGE, 2-MBGE, 1,2-DBGE, and 1,3-DBGE). Amberlyst-15 produced higher yields of propylation and butylation of glycerol than the S100 and S200 resins. PGEs, TPGEs, and BGEs were tested as octane boosters and cold flow improvers. These alkyl glycerol ethers will lower the cloud point of palm biodiesels that have been blended with diesel. They have the ability to boost the research and motor octane numbers of gasoline.

G. Vicente has done the etherification of glycerol with isobutylene to yield tert-butylated derivatives, sulfonic-acid-functionalized mesostructured silicas have demonstrated excellent catalytic conduct. The fuel additives di-tert-butylglycerols (DTBG) and tri-tert-butylglycerols (TTBG) have been shown to reduce emissions of particulate matter, hydrocarbons, carbon monoxide, and uncontrolled aldehydes. Similarly, said ethers can be used as cold flow improvers in biodiesel, lowering its viscosity. The activities and selectivities achieved over sulfonic acid-functionalized mesostructured silicas are comparable or even superior to those displayed by widely used macroporous commercial acid resins. Under optimized reaction conditions, these mesostructured catalysts yield a complete glycerol conversion with a combined selectivity towards DTBG and TTBG up to ca. 90%. Furthermore, no formation of undesirable isobutylene oligomers is observed. The acid strength of the sulfonic acid sites has also been found to be an important factor affecting the catalytic performance of these materials.

Gabriele Di Blasio has conducted research on the effects of a bio-derivable glycerol-based ethers mixture (GEM) on combustion and emissions have been investigated in a compression ignition engine. The experiments were carried out on a single-cylinder research engine that was derived from four-cylinder passenger car engine. The experiments were carried out in some of the New European Driving's most iconic locations. The experiments were carried out in some of the New European Driving's most iconic locations. Emission homologation cycle (NEDC). The effect of the blend on the output of a real four-cylinder engine (one of which is described by the research engine) over the NEDC could be estimated using these points. During the test campaign, both controlled and unregulated pollutant emissions were calculated. Apart from the controlled emissions, the concentration of aldehydes and carbonaceous particles in the exhaust of the engine has been calculated in some test points. The outcomes have been. There was a maximum reduction of about 70% in PM emissions at medium–high load conditions, compared to a marginal increase in NO_x. A maximum increase of about 50% in HC and CO has been observed at low load conditions. In terms of aldehyde emissions, the results revealed that adding GEM favoured the increase of carbonyl compounds at low engine loads, while burning GEM had no significant effect at higher loads.

M. Montiel has conducted research over the last few years, the production of biofuel has skyrocketed. Glycerol, a by-product of biodiesel production, makes up 10% of the overall product and has just a few uses. Glycerol etherification with light olefins (isobutene, isoamylenes) in liquid phase, catalysed by acidic macroporous ion-exchange resins, may be an appealing solution I to address excess glycerol and (ii) to increase diesel volume using light olefins, resulting in a product with good properties, higher value, and especially useful as an additive in diesel and also in bio. We performed comprehensive literature research to improve our understanding of glycerol etherification with light olefins in order to study the etherification of glycerol with isoamylenes accurately. Only isobutene without and with solvents, as well as tert-butyl alcohol, had been thoroughly studied experimentally. This paper demonstrates various synthetic paths, raw materials, and experimental conditions for obtaining high glycerol conversion and strong ether selectivities.

Fatih Yılmaz has conducted research on the etherification of glycerol with isobutene over cost-effective and commercially available solid acid catalysts will generate high yields of di- and tri-tert-butyl glycerol ethers (DTBGE and TTBGE). These ethers have the ability to substitute methyl-tert-butyl ether, a harmful gasoline oxygenate to the atmosphere. In this analysis, we first synthesised fuel additive mixtures containing various concentrations of DTBGE and TTBGE, and then used these mixtures to blend with a reference gasoline fuel to determine the fuel characteristics of the fuel surrogates. With increasing TTBGE concentration, the density, kinematic viscosity, and water solubility of the GTBE mixtures decreased, leading to a decrease in the number of hydroxyl groups in the ether mixtures. As 3.45 vol% GTBE was blended into gasoline, the octane number increased from 95 to 96 and the vapour pressure decreased from 57 to 55 kPa, while the density and oxidation stability of the GTBE-gasoline blends remained within the fuel requirements. The results showed that DTBGE alone is incompatible with gasoline, and that TTBGE content in fuel blends is needed for better compatibility. The results showed that DTBGE alone is incompatible with gasoline, and that TTBGE content in fuel blends is needed for better compatibility. We then conducted fuel efficiency tests in an engine dynamometer using the reference gasoline, 3.45 vol percent MTBE-blended gasoline, and 3.45 vol percent GTBE-blended gasoline to compare power and emissions (34 wt percent TTBGE, 62 wt percent DTBGE, 1 wt percent MTBGE, and 3 wt percent isobutene oligomers). Our findings show that GTBE is a viable substitute for MTBE in gasoline additives, as their blends produce similar torque values, specific fuel consumption, and CO₂, CO, NO_x, and total hydrocarbon emissions (THC).

Muhamad has conducted research on the scarcity of fossil fuels has prompted further research into and use of renewable energy sources like biodiesel. However, this has created a new problem in the form of a substantial rise in glycerol, a byproduct of the process. Due to the characteristics and potentials of glycerol, efforts to transform it into higher-value goods are increasing, which will boost the overall economics of biodiesel production. Biofuels, oxygenated fuel additives, polymer precursors, and other industrial bio-based chemicals are among these high-value items. This review presents the most recent research findings in the conversion of glycerol to the high-value products mentioned above, with a particular

emphasis on the performance of the catalysts used and their limitations. Hydrogen, ethanol, methanol, acetin, glycerol ethers, solketal, acetal, acrolein, glycerol carbonate, 1,3-propanediol, polyglycerol, and olefins are among the products discussed in this article.

Alper Uzun has made a research in 2020, the biodiesel industry is projected to add more than three million tonnes of glycerol to the market. To keep the sustainable glycerol and biodiesel industries afloat, various routes for producing glycerol-based value-added goods have been suggested. Catalytic etherification of glycerol with isobutene to produce fuel oxygenate glycerol ethers as an alternative to today's petroleum-based oxygenates is one of these paths. Mono-, di-, and tri-tertiary butyl ethers of glycerol (MTBG, DTBG, and TTBG) and dimers of isobutene are the components of etherification of glycerol with isobutene (DIB). Because of their better mixing properties, DTBG and TTBG are the preferred items for fuel blends. Different heterogeneous catalysts, such as acidic ion exchange resins (e.g. Amberlyst 15 and 36), sulfonated large pore zeolites (e.g. zeolite Beta and Y), sulfonated mesoporous silica (e.g. MCM-41 and SBA-15), and certain functionalized porous materials (e.g. sulfonated peanut shell, sulfon.

Muhammad Zaki gone through the emissions generated by automobile engines are one of the world's major causes of global warming. The global decline of conventional oil has prompted a number of researchers to look for alternative fuel options to replace petroleum. Various tests on additive fuels have also been conducted, with the majority of the fuels producing excellent performance. Citronella oil was blended into pure diesel fuel in this experiment to investigate emissions and fuel consumption in a single-cylinder diesel engine. Citronella oil can make up to 0.5 percent of diesel fuel blends. This experiment was conducted on a single-cylinder engine with three loads (25 percent, 50 percent, and 75 percent) and three different engine speeds. Experiments with diesel-citronella fuel show that CO₂ emissions are lower than with pure diesel. CO₂ emissions from the diesel-citronella mixture was reduced by 25% (0.4%), 50% (0.8%), and 75% (1.9%), respectively, for different engine loads. For each engine load and all speeds tested, the consumption of the diesel-citronella fuel blend is higher than pure diesel. Overall, the diesel-citronella mixed fuel performed better in all tests than pure diesel.

Carlo Beatrice made a paper presents the findings of a collaborative research project aimed at maximising the energy potential of biodiesel-derived glycerol. The aim of this study is to define and validate a synthesis method for converting glycerol into an oxygenated fuel additive (glycerol alkyl–ether) for use in diesel and biodiesel blends. The equipment, methodologies, and preliminary engine test results are listed, as well as a preliminary Life Cycle Assessment (LCA). Etherification of glycerol with tert-butyl alcohol and isobutylene enabled researchers to pinpoint the ideal experimental conditions for obtaining a mixture dominated by higher glycerol ethers (GEM). Novel catalysts based on perfluorosulphonic ionomers as active species and spherical silica as help were found to be stable and reusable, allowing for the production of mixtures with very low levels of monoethers and oligomers, which are considered undesirable by the researchers. As compared to neat diesel fuel and a combination diesel/biodiesel, engine tests with GEM blends in diesel fuels showed strong combustion and emission results. According to a life cycle assessment, the GEM/diesel blend has a lower environmental effect than straight diesel.

Ana-María has conducted research on the surplus bioglycerol from biodiesel production has little market value in the already saturated glycerol market. The synthesis of 1,3-di-tert-butoxypropan-2-ol as a fossil diesel/biodiesel portion is described in this paper. This latest application has the potential to increase the value of bioglycerol while also improving the properties and environmental efficiency of biodiesel. The synthesis is a three-step process that begins with the transformation of epichlorohydrin, which is obtained by using the new Solvay process to transform bioglycerol. In terms of selectivity, conversion, and yield, the overall method yields satisfactory performance. A spectroscopic analysis revealed that 1,3-di-tert-butoxypropan-2-ol is the most abundant of the process's by products, with only minor amounts of by products produced, indicating that the overall process is technically viable. There has also been an analysis of the net carbon dioxide emissions emitted by the combustion of this portion.

Rafael Estevez Biodiesel demand has risen dramatically in recent decades, resulting in a glut of crude glycerol, which is the process's biggest downside. To address this, many scientists have focused their efforts on developing

value-added products from glycerol, which has great potential as a platform molecule. Preparing oxygenate additives for fuel, especially those obtained by the etherification reaction of glycerol with alcohols or olefins, primarily using heterogeneous catalysis, is a promising choice. This analysis compiles the most recent research results on the etherification of glycerol, using either isobutene (IB) or tert-Butyl alcohol (TBA), and highlights the best catalytic performances recorded. In addition, the experimental sets used for these reactions have been used in this paper. Similarly, the properties of glycerol ethers–(bio) fuel blends, as well as their efficiency (e.g., pollution content, technological advantages or drawbacks, etc.) have been summarised and addressed.

Catia Cannilla has conducted research on the etherification of glycerol with (bio) butanol was studied in order to produce glycerol ethers that could be used as oxygenated diesel fuel additives. Experiments were carried out with the use of a tubular water-permselective membrane and a batch reactor. In order to maximise glycerol conversion, A-15 resin was used as a solid acid catalyst at temperatures ranging from 70 to 160 C. The water produced during the reaction was constantly eliminated by recirculating the gas phase through the membrane, allowing for improved reaction kinetics and the creation of poly-substituted ethers that would not have been possible without the membrane. Alcohol dehydration and selfetherification of glycerol or alkyl alcohols produce a number of side products that are currently difficult to recognise.

Andrey A. Smirnov has conducted research on one of the most appealing sources of renewable energy is biodiesel. It is made from the transformation of vegetable oils, with up to 10% of glycerol produced as a by-product. As a result, new approaches for processing bio-glycerol into value-added chemical compounds like solketals are needed. By acetalizing glycerol with an aldehyde or ketone, various six- and five-membered cyclic compounds can be produced. Glycerol oxygenates are good fuel additives because they increase viscosity, octane or cetane number, and oxidation stability. Furthermore, as compared to normal diesel fuel, these goods greatly minimise carbon monoxide emissions. We highlight recent developments in glycerol valorization for the long-term processing of bio-additives in this study. A

discussion of novel and possible catalysts for the production of solketals is included in the study.

V.O. Samoilov has made a survey over the key physico-chemical characteristics of eight diol derivatives, as well as gasoline blending characteristics (1,3-diisopropyl and 1,3-di-tert-butyl glycerol ethers – di-GIPE and di-GTBE; O-isopropyl and O-tert-butyl solketal ethers – SIPE and STBE; isopropylidene ketals of ethylene and prop. The density, boiling/melting point, viscosity, and net heat of combustion of the oxygenates have all been determined experimentally. The density, calorific weight, fractional composition, saturated vapour pressure, study octane number and motor octane numbers (ON), oxidation stability, gum content, and pour point are all characteristics of the approximate oxygenategasoline blends. The effect on the gasoline calorific performance has been researched in conjunction with the antiknock features enhancement for di-GTBES, as the most powerful octane booster, which reveals the obvious advantages over ethanol and MTBE in terms of ratio.

Carles Estevez has made a study over the past decade, the global boom of biodiesel fuels -FAME- has resulted in a surplus of glycerol (a by-product of biodiesel production) on the market, which has resulted in a price drop that has hampered the competitiveness of biodiesel plants. The attempts made to ensure biodiesel sustainability and eliminate the effects on the global food market and climate will not alter this reality: if the current and future glycerol stocks are to be handled, new options for glycerol are needed. This paper describes a novel chemical method that produces esters of glycerol formal -FAGE-, which can be used as a blending ingredient in diesel fuels, using waste oils and glycerol as reagents. For a hybrid FAME/FAGE product, the reaction could be incorporated into traditional biodiesel plants. Two FAGES obtained from cooking oil and animal fats were tested, as well as their blends with standard diesel fuel. Since pure FAGE has a high viscosity (greater than 10 mm² s⁻¹ at 40 C) and a low Cold Filter Plugging Point e CFPP (around 15 C), it must be blended with diesel fuel for automotive applications. Blends containing up to 20% FAGE by volume showed viscosity and CFPP within current legislative limits, while their improved derived cetane number, FAGE's

adiabatic flame temperature, which is similar to that of FAME, and high oxygen content suggest a positive NO_x-particulate trade-off in diesel engines.

V.O. Samoilova has conducted research on SME (solketal methyl ether) was made from glycerol by converting it to methanol and then ketalizing it with acetone. The equilibrium constants of ketalization of glycerol and glycerol 1-monomethyl ether were determined experimentally in the temperature range of 298–323 K, and their thermodynamic parameters (H^0 , S^0 , G^0) were measured, which tend to be very similar for these two reactions. The effects of solketal and SME additives on the fractional composition, saturated vapour pressure, oxidation induction time, existent gum content, density, and antiknock value of gasoline components and a model fuel blend were investigated in comparison to those of solketal. SME has been shown to have better volatility than solketal, but a much lower antiknock value. The antiknock value of components of compounded gasoline (alkylate, reformat, FCC gasoline) as well as the performance of composite additives based on solketal with ethanol, MTBE, and TAME are discussed.

Gemma Vicente has made the aim of this research is to generate ethyl ethers of glycerol that can be used as gasoline or diesel fuel biocomponents by etherifying biodiesel-derived glycerol with anhydrous ethanol over arenesulfonic acid-functionalized mesostructured silicas. $T = 200\text{ }^{\circ}\text{C}$, ethanol/glycerol molar ratio = 15/1, and catalyst loading = 19 wt% are the best conditions for maximising glycerol conversion and yield against ethyl-glycerols within the studied range. After 4 hours of reaction, 74 percent glycerol conversion and 42 percent yield to ethyl ethers were achieved, but there was a substantial presence of glycerol by-products. To prevent the formation of glycerol by-products and optimise ethyl-glycerols selectivity, lower reaction temperatures ($T = 160\text{ }^{\circ}\text{C}$) and moderate catalyst loading (14 wt%) are needed in the presence of a high ethanol concentration (ethanol/glycerol molar ratio = 15/1). Low-grade water-containing glycerol has been found to have similar catalytic performance to high-purity glycerol.

CHAPTER 3

MOTO OF THE PROJECT

Oil market shortages, rising petroleum prices, and the loss of fossil fuel supplies are all problems that the world is dealing with. Biodiesel is a vegetable-based fuel that has been marketed as a viable alternative to gasoline. A combination of diesel and a single biodiesel has been studied in the past. completed now Using two related biodiesel formulations, only a few experiments have been performed. Blends well with diesel and offers a lot of space for experimentation. The present thesis includes dealing with separate blending ratios of two biodiesels made from pongamia pinnata oil and mustard oil with diesel. The impact of dual biodiesel on engine performance and emissions was investigated. A single cylinder, direct injection, air cooled, high-speed diesel engine was tested at different speeds. The engine loads at 3000 rpm. Blended gas impact on CO, CO₂, HC, and other gases NO_x and smoke opacity were studied using emission methods. The thermal efficiency of Blend A's brakes was determined to be higher than that of diesel. Smoke, hydrocarbons, and nitrogen oxide emissions were higher in dual biodiesel blends than in ethanol. The temperature of the exhaust gas in dual biodiesel generators, on the other hand, is higher. Blended oils had a smaller proportion than diesel fuel. A single cylinder, direct injection, air cooled, high-speed diesel engine was tested at different speeds. The engine loads at 3000 rpm. Blended gas impact on CO, CO₂, HC, and other gases NO_x and smoke opacity were studied using emission methods. The thermal efficiency of Blend A's brakes was determined to be higher than that of diesel. Smoke, hydrocarbons, and nitrogen oxide emissions were higher in dual biodiesel blends than in ethanol. The temperature of the exhaust gas in dual biodiesel generators, on the other hand, is higher. Blended oils had a smaller proportion than diesel fuel.

3.1 REASONS WHY PETROLEUM IS HARMFUL TO THE ENVIRONMENT

It contributes to polluting pollution, especially carbon dioxide, one of the most harmful greenhouse gases, since it is a fossil fuel. Human emissions to greenhouse gases have changed the ozone greenhouse layer, which plays a vital role in controlling global temperatures.

3.2 RESULTS OF GLOBAL WARMING

The consequences of global warming on habitats include temperature increases, water scarcity, intensified fire risks, drought, weed and pest invasions, severe storm destruction, and salt invasion, to name a few. The Great Barrier Reef, one of Australia's most prominent natural attractions, is now in jeopardy.

3.3 BIODIESEL BENEFITS AND CONSIDERATIONS

Biodiesel is a domestically produced, clean-burning, renewable substitute for petroleum diesel. Using biodiesel as a vehicle fuel increases energy security, improves air quality and the environment, and provides safety benefits.

3.4 ENERGY SECURITY AND BALANCE

The United States imported 3% of its petroleum in 2019, and the transportation sector accounts for approximately 30% of total U.S. energy needs and 70% of U.S. petroleum consumption. Using biodiesel and other alternative fuels and advanced technologies to reduce fuel consumption continues to strengthen national security and reduce transportation energy costs for businesses and consumers.

Biodiesel is produced in the United States and used in conventional diesel engines, directly substituting for or extending supplies of traditional petroleum diesel. Soybean biodiesel has a positive energy balance, meaning that soybean biodiesel yields 4.56 units of energy for every unit of fossil energy consumed over its life cycle.

3.5 AIR QUALITY

Engines manufactured in 2010 and later must meet the same emissions standards, whether running on biodiesel, diesel, or any alternative fuel. Selective catalytic reduction (SCR) technology in diesel vehicles, which reduces nitrogen oxide (NO_x) emissions to near-zero levels, makes this possible. The emissions from engines using diesel fuel are comparable to those from biodiesel blends.

Using biodiesel reduces life cycle emissions because carbon dioxide released from biodiesel combustion is offset by the carbon dioxide absorbed from growing soybeans or other feedstocks used to produce the fuel. Life cycle analysis completed by Argonne National Laboratory found that B100 use reduces carbon dioxide emissions by 74% compared with petroleum diesel. The California Air Resources Board (CARB) reported similar values from various sources for its life cycle analysis of biodiesel.

Air quality benefits of biodiesel are roughly commensurate with the amount of biodiesel in the blend. Learn more about biodiesel emissions.

3.6 ENGINE OPERATION

Biodiesel improves fuel lubricity and raises the cetane number of the fuel. Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely. One unintended side effect of the federal regulations, which have reduced allowable fuel sulfur to only 15 ppm and lowered aromatics content, has been to reduce the lubricity of petroleum diesel. To address this, the ASTM D975 diesel fuel specification was modified to add a lubricity requirement (a maximum wear scar diameter on the high-frequency reciprocating rig [HFRR] test of 520 microns). Biodiesel can increase fuel lubricity to diesel fuels at blend levels as low as 1%.

Before using biodiesel, check your engine original equipment manufacturer (OEM) recommendations to determine what blend is optimal for your vehicle (see the National Biodiesel Board's OEM Information for those that support the use of biodiesel blends).

3.7 SAFETY

Biodiesel in its pure, unblended form causes far less damage than petroleum diesel if spilled or released to the environment. It is safer than petroleum diesel because it is less combustible. The flashpoint for biodiesel is higher than 130°C, compared with about 52°C for petroleum diesel. Biodiesel is safe to handle, store, and transport. For additional guidance on handling, storing, and transporting biodiesel, reference the Biodiesel Handling and Use Guide.

CHAPTER 4

EXPERIMENTAL SETUP

A single cylinder, constant speed, Direct injection engine was used to evaluate the engine performance and emission characteristics of bergamot bio diesel. The diesel runs under different load conditions at a constant speed of 1500 rpm with the different blend proportions. The diesel engine was directly attached with an eddy current dynamometer for varying the loads from no load (0%) to full load (100%). Based on the engine power, the engine load is varied from no load condition of 0%, 25%, 50%, 75% and full load conditions of 100%. The engine loads are varied manually with help of an eddy current dynamometer. Air flow rate was measured with an air drum fitted with a calibrated orifice and the fuel flow was measured using volumetric calibrated burette method. For fuel flow measurement, two fuel tanks were used; one is filled with pure diesel while transesterified bergamot biodiesel is filled in another fuel tank. An AVL smoke meter was attached for measuring the smoke opacity and exhaust gas temperatures. The test rig was installed with AVL indimicro software to obtain various readings and results during operation. A five gas analyzer was used to measure the emission characteristics such as HC, CO, CO₂, O₂ and NO_x values from the exhaust gas.

The performance and emission tests were conducted at the compression ratio of 17.5 and with rated power.

The test was carried out for different blend proportions of bergamot biofuel blended with the pure diesel fuel. The performance analysis of the engine at different rated power was evaluated in terms specific fuel consumption (SFC), Brake thermal efficiency (BTE) and emissions characteristics such as HC, CO, CO₂, and NO_x. Figure shows the photographic view of the experimental setup used in this study.



Figure 4.1 Photographic View of the Experimental Setup

Table 4.1 Specifications of the Test Engine

Engine type	Single cylinder ,4 stroke ,water cooled engine
	Stroke 110mm, bore 87.5mm, 661cc
Power	5.20kw @1500rpm
Compression	17.5
Injection variation	0-25 degbTDC
Dynamometer	Eddy current, water cooled with loading unit
Fuel tank	15 it, Dual compartment with fuel metering

Engine soft is lab view based software package developed by Apex innovations Pvt. Ltd. For engine performance monitoring system. Engine soft can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. The software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine is run mode necessary signals are scanned, stored and presented in graph. While on line testing of the engine in RUN mode necessary signals are scanned, stored and presented in graph. Stored data file is accessed to view the data graphical and tabular formats. The results and graph can be printed. The data in excel format can be used for further analysis.

4.1 TEST RUN WITH COMPUTERIZED MULTI CYLINDER ENGINE SETUPS

- Ensure that all the nut bolts of engine, dynamometer, propeller shaft, base frame are properly tightened.
- Ensure that sufficient lubrication oil is present in the engine sump tank. This can be checked by marking on the level stick.
- Ensure sufficient fuel in fuel tank. Remove air in fuel line, if any.

- Switch on electric supply and ensure that PPU (piezo powering unit AX-409), DLU (dynamometer loading unit AX-155), load indicator and voltmeter are switched on.
- Start computer and open “ICENGINESOFT” (double click “ICENGINESOFT” icon on the desktop) select :File| configure | product
- In “configure the product “ windows select “load default”
- Under “select file” choose your setup from drop down menu
- Under “set parameters” the under ok. Study parameters engine, sensors, combustion and performance tabs. Click on
- Changing the parameters:
- If any parameter changed click “New /change the parameter under respective tabs .After all change click “Save & Apply “. Click “ok” to save changes.
- Click “OK” again to reconfigure changes C.
- Reconfigure the graphs.
- Select file | configure | Graph. Under “Configure the Graphs” window. “Select a configuration “from the drop down menu.
- “CLOSE & SET” click “SAVE” study the preset configuration of X axis, Y axis, graph ranges, for the selected graphs. Click configure the necessary parameter ranges as required.
- Then “Close and SET”
- Note three vertical tabs viz. combustion, performance, report. Under vertical combustion tab horizontally following tabs are available: combustion, cylinder pr. pv, Log PV and RPR etc. Similarly under other vertical tabs we get more horizontal tabs. Start water pump. Adjust the flow rate of “Rotameter (Engine)” to 900-1000 LPH and

“Rotameter (calorimeter)” to 200-250 LPH by manipulating respective globe values provided at the rotometer inlet. Ensure that water is flowing through dynamometer at a pressure of @ 0.5 to 1 kg/cm². (For Hydraulic dynamometer at a pressure of @ 1.5 to 2 kg/cm²)

- Keep the DLU knob at minimum position. Change the fuel cock position from “Measuring”.
- “Tank”. start the engine by starter keys switch and allow it to run at idling condition for 4-5 minutes.

4.2 ONLINE DATA ACQUISITION

“Mode” “Measurement” click toggle switch to start/stop the device communication. Green color indicates ON condition. Click toggle switch to start/stop data acquisition. Green color indicates ON condition.

Ensure that speed, temperature and manometer reading are correctly displayed on the pc. These readings should tally with those displayed on the engine panel.

Increase the load on the engine by rotating knob on the DLU and confirm the load reading on the indicator and computer are same.

Gradually increase throttle to full open condition and load the engine simultaneously maintaining engine speed at @2000-2500 RPM. Flow, calorimeter jacket cooling water flowing LPH click “OK” after.

Wait for steady state for @ 3minutes and ensure that RPM & load is constant during this period. Change the fuel cock position from “tank” to “measuring”. Click “log on” on. The fuel metering is ON for next 60 seconds. During first 30 seconds enter engine water recording fuel reading. Enter the file name under which the records to be stored. The first reading data is now saved. Change the fuel cock position from “Measuring” to “Tank”.

Gradually decrease the load to the increase speed in steps of @500 RPM up to @ 4000 rpm maximum and repeat the data logging for each observation.

After finishing all the readings simultaneously decrease the load on the engine by DLU. Gradually decrease throttle to full down condition.

“Measureme” ”Mode” click toggle switch to stop data acquisition on PC (Green color indicates ON condition). Click toggle switch to stop the device communication

Click: File | Data | close. Stop the engine by pressing engine stop starters keys. Allow the water to circulate for about 5 minutes for engine cooling and then stop the pump.

Click: File | Data | open .on PC, select the File under which the readings are stored and click “OK”. To view next readings click “Next Data”. The results are displayed on all the three screens.

Click tab for performance Enter File name “Report File” .Select Report Printing: Report generating Report, combustion Report.

The Report Requirement viz. Result data, Observation Data .Graph only OR Graph and Table. (Note if “Graph and Table”) options selected under.

Combustion report, the size of the output file for printing becomes too big. However it can be viewed in Excel) Click: File | Data | Close. After printing & checking .Click “Exit” and then shut Down the computer.

4.3 SMOKEMETER

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

- Kindly fill the details (Engine No. Model, Engine Type, Engine Speed) in respective text boxes given on the form if you didn’t check “Vehicle details”

check box in Master data entry form all the textboxes related to (Engine No. Model, Engine Type, Engine Speed) becomes disabled.

- Click on “Connect button” to connect the PC with equipment and wait for 5-10 seconds. If the readings are not coming it show the message in red colour” Unable to Communicate with Equipment” kindly check the following:
- Be sure that Smokemeter model name display on screen is same as your smokemeter model if not kindly change the model in “Master Data Entry Form”.
- Check the COM port settings with PC and the software in “Master Data Entry” Form.
- RS232 Cable for smokemeter is working properly and connected with equipment.
- Readings are coming with equipment and display on remote of smokemeter.
- According to “Time interval settings in selection box, readings are automatically saves in database”.
- After taking the readings click on “Disconnect button” it disconnect the communication with equipment and show the message “Disconnected”.
- Report: Click on report button to take the report of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel sheet: To export data in excel sheet click on “EXPORT TO EXCEL” button. When pressing export button a excel file is generated at path “C:\ AVLFolder\”.The file name of excel file is same as Test Date and VIN no(Tuesday, January 06, 2009_26).

- Close button: click on close button to exit from current active window or screen, it takes time to close, so wait for 10-15 seconds for form window to close.



Figure 4.2 Smokemeter



Figure 4.3 Linearity Test

4.4 GAS ANALYZER

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

- Kindly fill the details (Engine No.Model, Engine Type, Engine Speed)in respective text boxes given on the form.
- Click on “Connect button” to connect the PC with equipment and wait for 2-3 minutes. If the readings are not coming it show the message in red colour “CO HC power not communicating.” Kindly check the following:
- Be sure that gas analyzer setting in “MAHA Euro”mode.
- Check the COM port settings with PC and the software.
- RS232 Cable is working properly and connected with equipment.
- Readings are coming with equipment and display on panel.
- After 6 seconds readings are automatically save in database and status bar strip moving according to readings save in database.
- After taking the readings click on “Disconnect button” it disconnect the communication with equipment and show the message “Data Saved in Database”.
- Report: Click on report button to take the report of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel sheet: To export data in excel sheet click on “EXPORT TO EXCEL”button.When pressing export button a excel file is generated in a path “C:\ AVLFolder\”.The file name of excel file is same as Test Date and VIN no(Tuesday, January 06,2009_23).
- Close button: click on close button to exit from current active window or screen.



Figure 4.4 Five Gas Analyzer Reading



Figure 4.5 Five Gas Analyzer

CHAPTER 5

RESULT AND DISCUSSION

Experiments were carried out on a 4-cylinder direct-injection diesel engine using biodiesel as an alternative fuel and their blends to investigate the engine's emission characteristics under four engine loads at 1800 rev/min. An engine was run on diesel and four different diesel/biodiesel blends as part of a test (B20, B40, B60 and B80). The results were analysed after being made from (OSO&BO) oil.

5.1 BREAK THERMAL EFFICIENCY

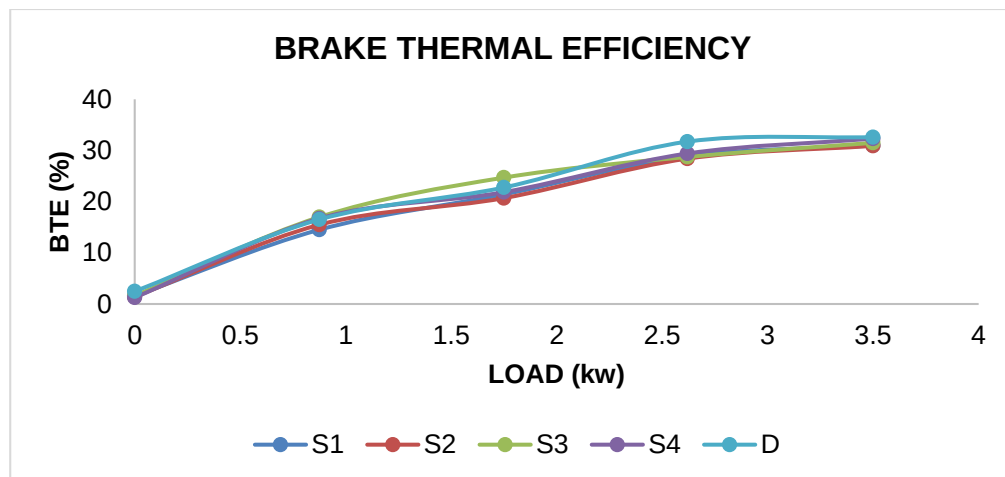


Figure 5.1 BTE Vs BP

BP(kw)	S1	S2	S3	S4	D
0	1.58	1.4	1.58	1.25	2.45
0.875	14.5	15.47	16.98	16.7	16.49
1.75	21.4	20.68	24.7	21.85	22.75
2.62	28.87	28.4	28.74	29.4	31.71
3.5	30.95	30.89	31.5	32.3	32.59

The above graph indicates the break thermal efficiency of a DI diesel engine using fuel. The above sample 3 (15WCO85D30PPMC8H180) shows a high break efficiency performance when compared with other samples. Overheating, brake fade and brake pad degradation are just a few. Current on-road diesel engines have approximately 42% brake thermal efficiency at full load, with 28% of fuel energy wasted in exhaust gas (including 4% going to pumping loss), 28% of fuel energy dissipating to cooling media as heat rejections to the ambient (including 4% going to mechanical friction and parasitic).

5.2 SPECIFIC FUEL CONSUMPTION

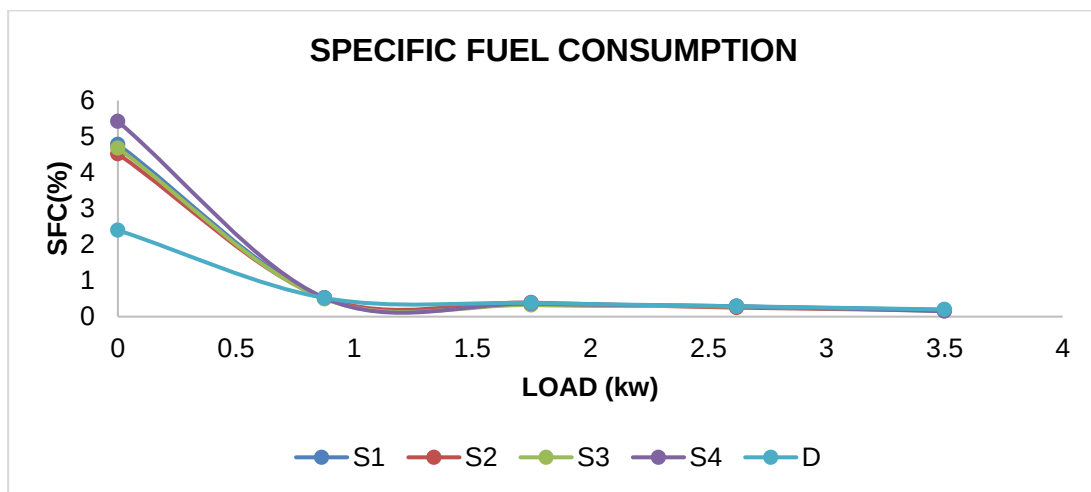


Figure 5.2 SFC Vs BP

BP(kw)	S1	S2	S3	S4	D
0	4.78	4.52	4.68	5.42	2.4
0.875	0.52	0.52	0.49	0.52	0.52
1.75	0.34	0.39	0.32	0.36	0.38
2.62	0.28	0.25	0.28	0.29	0.29
3.5	0.19	0.18	0.16	0.15	0.2

The above graph indicates the specific fuel consumption of a di diesel engine using dual fuel. The above graph shows that the fuel consumed during the ignition. The above tells that the sample 2 shows the less fuel consumed when compared with others samples and diesel. Sample 2 (10WCO90D30PPMC8H180).

The specific fuel consumption is defined as the rate of fuel consumption per unit brake power. It gives required to deliver one kilowatt for one hour at the load considered. Its unit is kg/KWh.

5.3 CO₂ EMISSION ANALYSIS

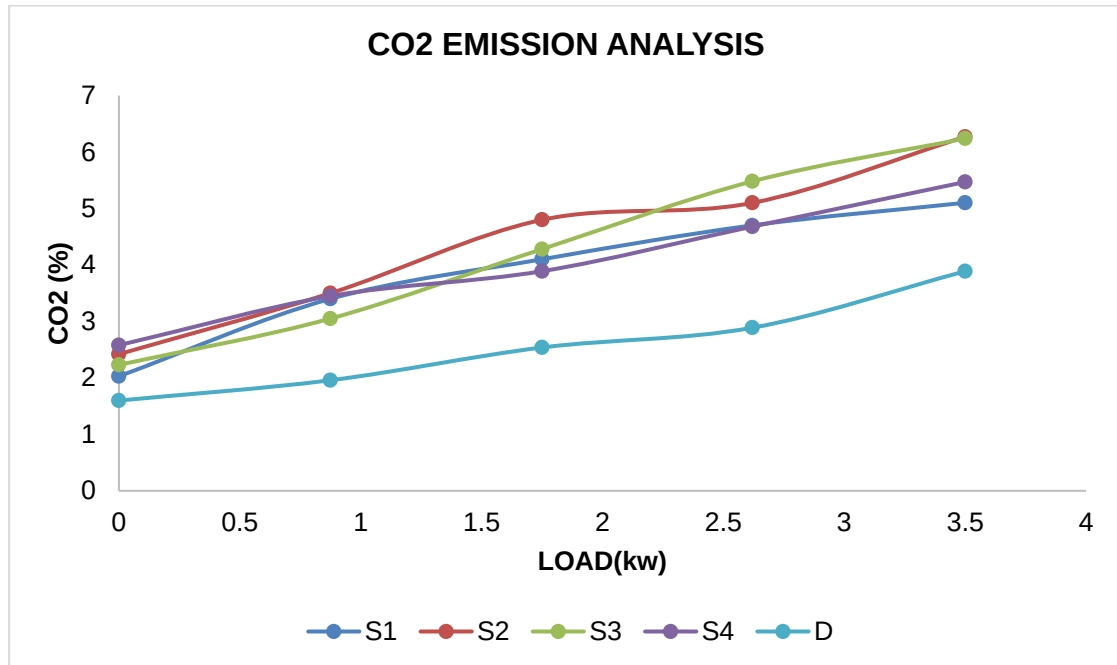


Figure 5.3 CO₂ Vs BP

BP(kw)	S1	S2	S3	S4	D
0	2.03	2.42	2.23	2.58	1.6
0.875	3.4	3.5	3.05	3.45	1.96
1.75	4.1	4.8	4.28	3.89	2.54
2.62	4.7	5.1	5.48	4.68	2.89
3.5	5.1	6.27	6.24	5.47	3.89

Carbon dioxide (CO₂) makes up the vast majority of greenhouse gas emissions from the sector, but smaller amounts of methane (CH₄) and nitrous oxide (N₂O) are also emitted. These gases are released during the combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity.

The above sample represent the emission of CO₂ for a given fuel. The above sample 1 produces less CO₂ emission and consume less diesel.

Sample1 (5WCO95D30PPMC8H180).

5.4 O₂ EMISSION ANALYSIS

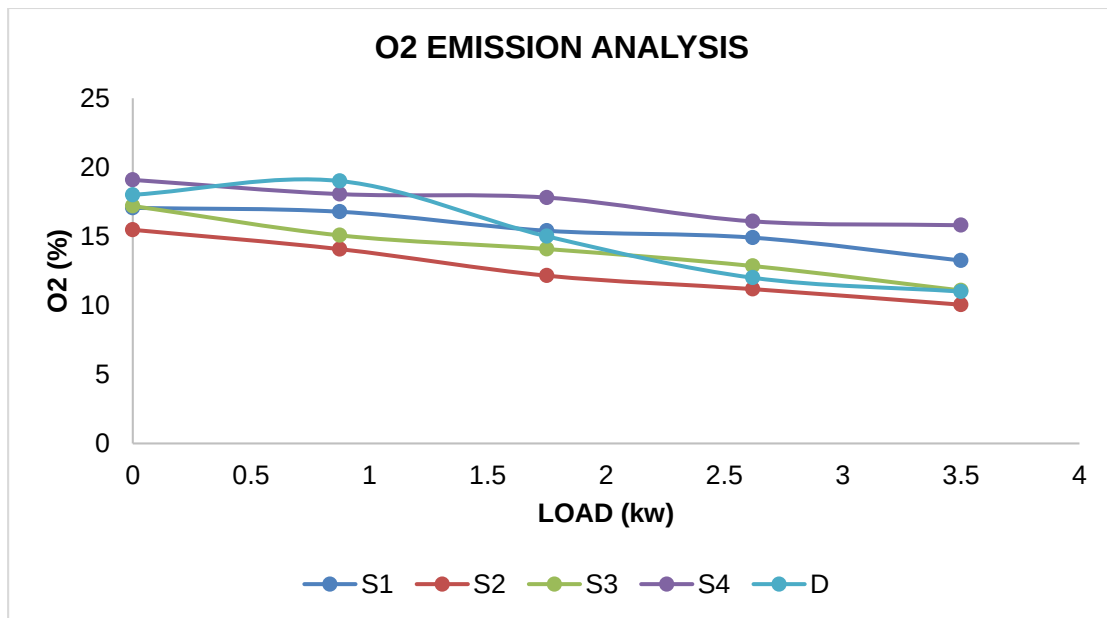


Figure 5.4 O₂ Vs BP

BP(kw)	S1	S2	S3	S4	D
0	17.06	15.47	17.2	19.08	18
0.875	16.78	14.07	15.07	18.05	19
1.75	15.4	12.15	14.08	17.8	15
2.62	14.9	11.18	12.85	16.08	12
3.5	13.24	10.05	11.08	15.8	11

O₂ = Oxygen, concentration of the exhaust in percent of the total sample. Free **O₂** occurs in the exhaust when there is an excess of air in the mixture.

The above sample represent the emission of O₂ for a given fuel. The above sample 4 produces high O₂ emission and consume less diesel.

Sample4 (20WCO80D30PPMC8H180).

5.5 CO EMISSION ANALYSIS

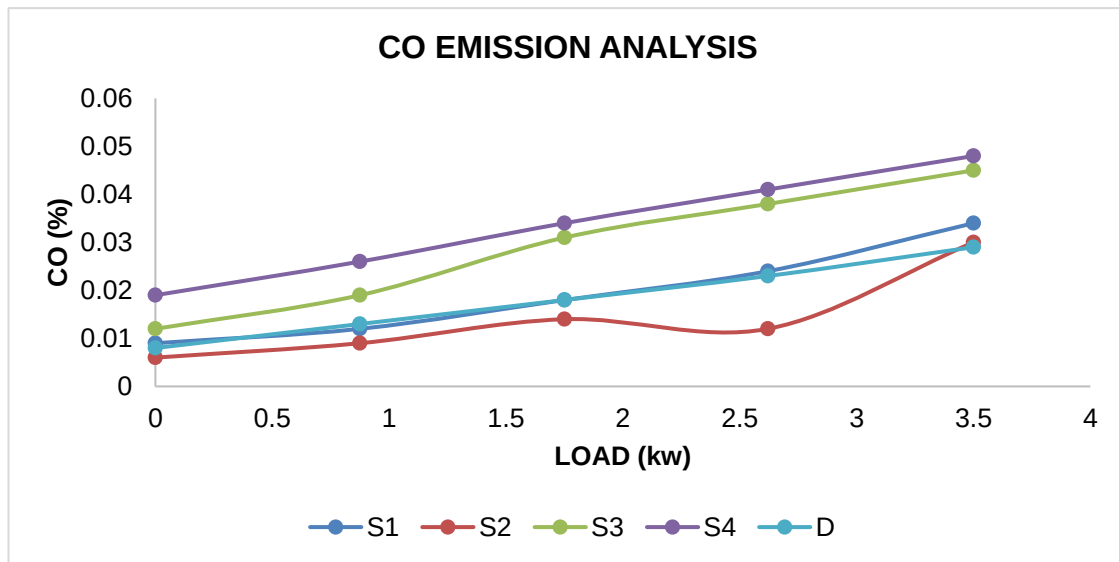


Figure 5.5 CO Vs BP

BP(kw)	S1	S2	S3	S4	D
0	0.009	0.006	0.012	0.019	0.008
0.875	0.012	0.009	0.019	0.026	0.013
1.75	0.018	0.014	0.031	0.034	0.018
2.62	0.024	0.012	0.038	0.041	0.023
3.5	0.034	0.03	0.045	0.048	0.029

Carbon monoxide (CO) gas forms primarily when carbon fuels are not burned completely. Other sources of **CO emissions** include industrial processes, non-transportation fuel combustion, and natural sources, such as forest wildfires. The **CO** Concentrations indicator describes health hazards associated with inhaling **CO**.

The above sample represent the emission of CO for a given fuel. The above sample 2 produces less CO emission and consume less diesel.

Sample2 (10WCO90D30PPMC8H180).

5.6 HC EMISSION ANALYSIS

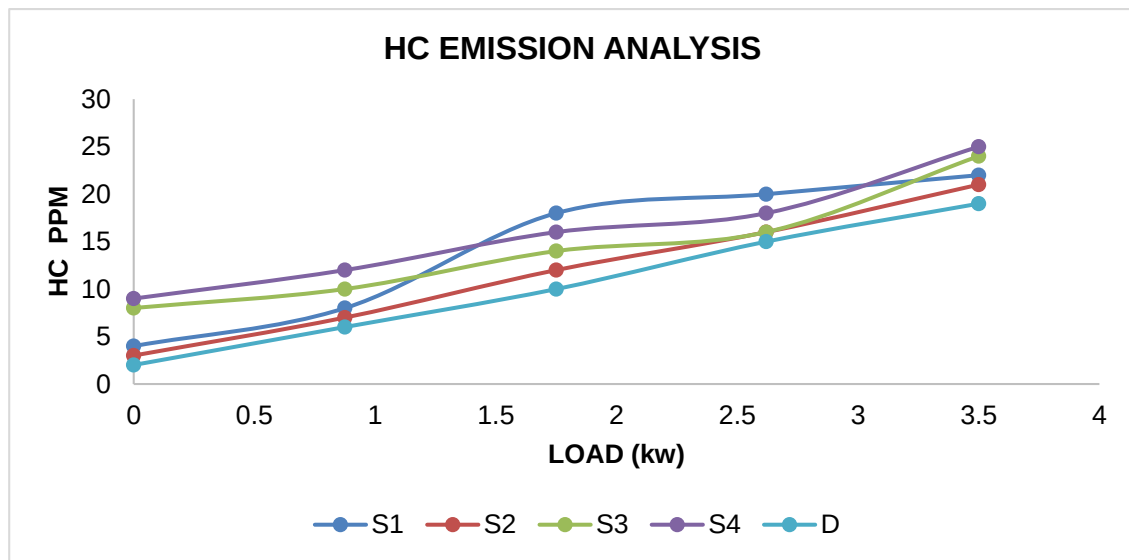


Figure 5.6 HC Vs BP

BP(kw)	S1	S2	S3	S4	D
0	4	3	8	9	2
0.875	8	7	10	12	6
1.75	18	12	14	16	10
2.62	20	16	16	18	15
3.5	22	21	24	25	19

Emissions that are principal pollutants of concern include: Hydrocarbons (HC) - A class of burned or partially burned fuel, hydrocarbons are toxins. Hydrocarbons are a major contributor to smog, which can be a major problem in urban areas.

The above sample represent the emission of hc for a given fuel. The above sample 2 produces less hc emission and consume less diesel.

Sample 2 (10WCO90D30PPMC8H180).

5.7 NO_x EMISSION ANALYSIS

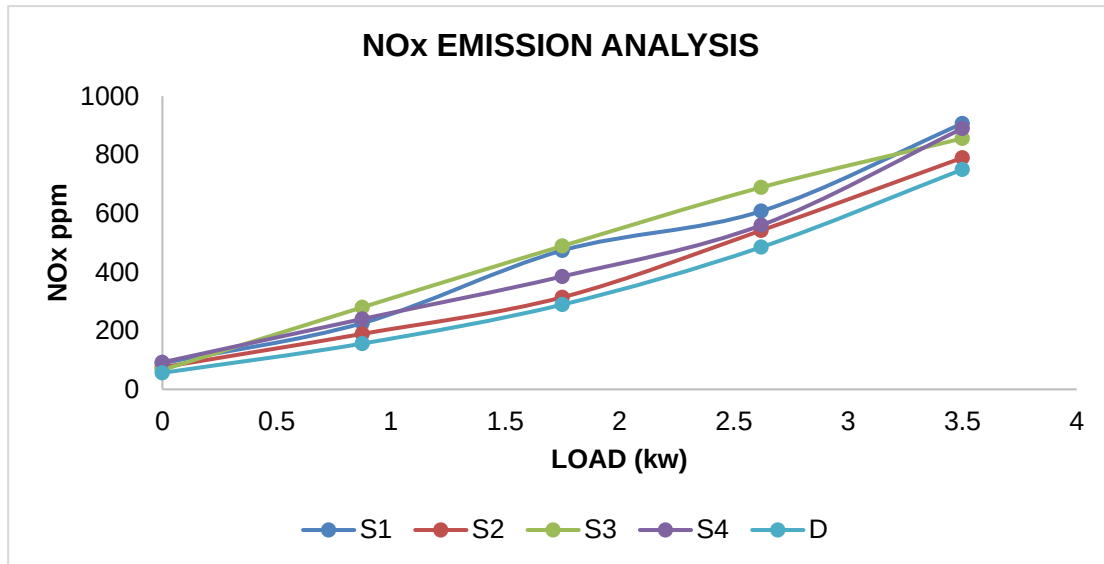


Figure 5.7 NO_x Vs BP

BP(kw)	S1	S2	S3	S4	D
0	89	75	66	92	56
0.875	226	189	280	240	156
1.75	474	314	489	385	289
2.62	608	542	689	560	485
3.5	907	790	856	890	750

Nitrogen Oxides (NO_x) Control Regulations. ... **Nitrogen Oxides** are a family of poisonous, highly reactive gases. These gases form when fuel is burned at high temperatures. **NO_x** pollution is emitted by automobiles, trucks and various non-road vehicles (e.g., construction equipment, boats, etc.)

The above sample represent the emission of NO_x for a given fuel. The above sample 4 produces less NO_x emission and consume less diesel.

Sample 4 (20WCO80D30PPMC8H180).

CHAPTER 6

CONCLUSION

In this work, the diesel engine is tested at various loads to investigate the combustion, performance and emission characteristics of four stoke engine fuel. About 30 liters of used waste cooking oil were collected from big restaurants out of which one liter was first used for demonstrations. Thereafter, more 28 liters of biodiesel were produced which were used both for the fuel property determination and engine performance analysis. By transestrification process we have produced a biodiesel production which low viscosity and others properties as mentioned above. Now coming to the emission characteristics we have found that the (BTE) brake thermal efficiency and oxygen content should be high for the emission. overheating, brake fade and brake pad degradation are just a few. Specific fuel consumption (SFC) is one of the most important metrics employed in aviation. And the emission of HC, CO, NOX, O₂, and CO₂. From diesel to B80, the NO_x emission increases. The main disadvantage of using a biodiesel-diesel mix is the rise in NO_x emissions, which can be mitigated by using water. Heat, Higher HC and CO emissions are generated, which can be mitigated by using metal-based nanoparticles.

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