

ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF BIO LUBRICANT WITH PROSOPIS SEED OIL

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Technology Degree in Chemical Engineering

By

KADHIRAVAN P (39690005)

PRABHAKARAN S (39690011)



**DEPARTMENT OF CHEMICAL ENGINEERING
SCHOOL OF BIO & CHEMICAL ENGINEERING**

SATHYABAMA

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

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119

OCTOBER 2022



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF CHEMICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **KADHIRAVAN P (Reg. No. 39690005)** and **PRABHAKARAN S (Reg. No. 39690011)** who carried out the project entitled **"ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF BIO LUBRICANT WITH PROSOPIS SEED OIL"** under our supervision from July 2022 to October 2022.

Internal Guide

Dr.D.PRABU, M.S (By Research),Ph.D

Associate Professor

External Guide

Dr. Mohamed Abbas

Head, Product and Research &
Developments, Hoist Industries

Head of the Department

Dr.S.SATHISH, M.E.,Ph.D

Associate Professor

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I, **KADHIRAVAN P** (Reg. No.39690005) hereby declare that the Project Report entitled “**ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF BIO LUBRICANT WITH PROSOPIS SEED OIL**” done by me under the guidance of **Dr. D. PRABU, M.S (By Research), Ph.D.**, Associate Professor, Department of Chemical Engineering, Sathyabama University and **Dr. Mohamed Abbas**, Head, Product and Research & Developments, Hoist Industries is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in **Chemical Engineering**.

DATE:
PLACE:

SIGNATURE OF THE CANDIDATE
KADHIRAVAN P

DECLARATION

I, **PRABHAKARAN S (Reg. No.39690011)** hereby declare that the Project Report entitled “**ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF BIO LUBRICANT WITH PROSOPIS SEED OIL**” done by me under the guidance of **Dr. D. PRABU, M.S (By Research), Ph.D.**, Associate Professor, Department of Chemical Engineering, Sathyabama University and **Dr. Mohamed Abbas**, Head, Product and Research & Developments, Hoist Industries is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in **Chemical Engineering**.

DATE:
PLACE:

SIGNATURE OF THE CANDIDATE
PRABHAKARAN S

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of SATHYABAMA for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. S. SATHISH, M.E., Ph.D.**, Head of the Department of Chemical Engineering for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guides **Dr. D. PRABU, M.S (By Research).**, **Ph.D.**, Associate Professor, Department of Chemical Engineering Sathyabama University and **Dr. Mohamed Abbas**, Head, Product and Research & Developments, Hoist Industries for his valuable guidance, suggestions, and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the **Department of Chemical Engineering** who were helpful in many ways for the completion of the project.

KADHIRAVAN P

PRABHAKARAN S

ABSTRACT

In the context of this study, biolubricant is going to be made from Prosopis seed oil using two-stage procedures. First, an ester of the oil called methyl ester is going to be formed, and then the oil is going to be transesterified with the help of a homogeneous catalyst (NaOH). After that, it is mixed with 15W/W% of sodium lauryl sulfate (SLS) to generate bio-lubricant. By altering the quantity of homogeneous catalyst that is used (1.0-1.2W/W%), two different grades of bio lubricant sample are to be made. The bio lubricant has a flash point that is roughly higher than 160 degrees Celsius. It is possible to employ bio-lubricants at a broad variety of temperatures since this is one of their characteristics. In this experiment, our bio lubricant is combined with conventional lubricant oil in varying quantities. The resulting mixtures are then tested for their effects on the performance and emissions of diesel engines. The results are on par with the traditional lubricant criteria for motor lubrication (SAE 20W40).

Keywords: Bio-lubricant, sodium lauryl sulphate, castor oil, , motorlube, transesterified, esterification & diesel engine.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	i
	TABLE OF CONTENTS	ii
	LIST OF FIGURES	v
	LIST OF TABLES	vii
	LIST OF SYMBOLS	viii
1	CHAPTER	1
1.1	INTRODUCTION	1
1.2	ITEMS REQUIRED	3
1.3	DESCRIPTIONS OF MATERIAL	4
1.3.1	MACHINE EXPELLER	4
1.3.2	METHANOL	4
1.3.3	BEAKER	5
1.3.4	MEASURING JAR	5
1.3.5	THERMOMETER	6
1.3.6	GLASS STIRRING ROD	6
1.3.7	TEST TUBE	7
1.3.8	STIR BAR OR MAGNETIC PELLET	7
1.3.9	HOT PLATE	8
1.3.10	SODIUM HYDROXIDE (NaOH)	9
1.3.11	WEIGHING SCALE	9
1.3.12	FILTER PAPER	10
1.3.13	DATA ACQUISITION SYSTEM	10
1.3.14	MAGNETIC STIRRER	11
2	CHAPTER	12
2.1	LITERATURE SURVEY	12
3	CHAPTER	15
3.1	AIM AND OBJECTIVE OF THE PRESENT INVESTIGATION	15
3.1.1	AIM AND OBJECTIVE	15
3.1.2	METHODOLOGY	16

4	CHAPTER	17
4.1	NECESSITY FOR IMPROVING ENGINE PERFORMANCE	17
4.2	THEORETICAL STUDY OF EXPERIMENTAL SETUP	17
4.2.1	STROKE ENGINE	17
4.2.2	CONSTANT PRESSURE CYCLE	18
4.3	DESCRIPTION ABOUT COMPONENTS	18
4.3.1	DIESEL ENGINE	19
4.3.2	SPECIFICATION OF DIESEL ENGINE	20
4.3.3	DATA ACQUISITION SYSTEM	20
4.3.4	EXPERIMENTAL WORKS	22
4.4	TYPES	24
4.4.1	MAGNETIC MINI STIRRER	24
4.4.2	MAGNETIC STIRRER WITH TIMER	25
4.4.3	HEAVY DUTY MAGNETIC STIRRER	25
4.4.4	BATTERY POWERED MAGNETIC STIRRER	25
4.4.5	AIR OPERATED TURBINE MAGNETIC STIRRER	25
4.5	WORKING	26
4.6	FUNCTION USES	26
4.7	BENEFITS	26
4.8	SPECIFICATIONS	26
4.9	PROSOPIS SEED OIL	27
4.10	U-TUBE MANOMETER	28
4.11	DATA ACQUISITION SYSTEM	29
4.12	LOAD SYSTEM	29
4.13	GENERATOR AND SPECIFICATIONS	29
4.14	FUEL TANK AND SPECIFICATIONS	30
4.15	PRESSURE GAUGE	31
4.16	MEASURING JAR	31
4.17	VOLTAGE REGULATOR	32
5	CHAPTER	33
5.1	EXPERIMENTAL RESULTS AND DISCUSSIONS	33
5.2	FORMULA USED	33
5.2.1	INDICATED POWER	33
5.2.2	BRAKE POWER	33

5.2.3	FRICTION POWER	33
5.2.4	EFFECTIVNESS PRESSURE	34
5.2.5	INDICATED MEAN EFFECTIVE PRESSURE	34
5.2.6	BRAKE MEAN EFFECTIVE PRESSURE	34
5.2.7	EFFICIENCY	34
5.3	CHEMICAL TEST RESULT	36
5.4	COMBUSTION RESULT	36
5.5	PERFORMANCE RESULT	41
5.6	EMISSION RESULT	44
CONCLUSION		48
REFERENCES		49

LIST OF FIGURES

FIGURE NO		PAGE NO
1.1	Oil Extraction Machine	4
1.2	Methanol	4
1.3	Beaker	5
1.4	Measuring Jar	5
1.5	Thermometer	6
1.6	Glass Stirring Rod	6
1.7	Test Tube	7
1.8	Stir bar or Magnetic Pellet	7
1.9	Hot Plate	8
1.10	Sodium Hydroxide	9
1.11	Weighing Scale	9
1.12	Filter Paper	10
1.13	Magnetic Stirrer	11
4.1	Diesel Engine	19
4.2	Prosopis Juliflora Seed Oil	21
4.3	Testing Machine	22
4.4	Smoke Meter	22
4.5	Gas Analyser	23
4.6	Dynometer	23
4.7	Schematic Diagram of Engine Setup	24
4.8	U-Tube Manometer	28
4.9	Fuel Tank	30
4.10	Pressure Gauge	31
4.11	Measuring Jar	32
4.12	Voltage Regulator	32
5.1	Rate of Pressure Rise Bar/Deg F	36
5.2	Net Heat Release J/Deg	37
5.3	Cumulative Heat Release KJ	37
5.4	Pressure Bar Vs Crank Angle Deg. F	38

5.5	Rate of Pressure Rise Bar/Deg F	38
5.6	Net Heat Release of Pressure Rise Bar/Deg. F	39
5.7	Cumulative Heat Release KJ	39
5.8	Pressure bar Vs Crank angle deg F	40
5.9	Rate of Pressure Bar/Deg F	40
5.10	Cylinder Pressure Bar	41
5.11	Break Power	42
5.12	Rate of Pressure Bar/Deg F	42
5.13	Break Thermal Efficiency %	43
5.14	Specific Fuel Consumption	43
5.15	Mechanical Efficiency %	44
5.16	Carbon Monoxide Emission %	44
5.17	Hydrocarbon PPM	45
5.18	CO2 % Comparison	46
5.19	O2 % Comparison	46
5.20	NOX PPM Comparison	47

LIST OF TABLES

TABLE NO	TITTLE	PAGE NO
5.1	Engine Test Results	36
5.2	Performance Results	41
5.3	Comparison	44
5.4	Hydrocarbon PPM	45
5.5	CO2 % Comparison	45
5.6	Oxygen % Comparison	46
5.7	NOX PPM Comparisons	47

LIST OF SYMBOLS

Symbols	Description
η_{gen}	Genrator Efficiency, %
P_{bm}	Break mean effective pressure
η_{vol}	Volumetric Efficiency
q_{act}	Actual Mass flowrate

CHAPTER – 1

1.1 INTRODUCTION

Products that are safer for the environment, as well as those that are dependable, long-lasting, and energy-efficient, are of high interest in the automobile and equipment industries. Some of the ways in which environmental problems caused by vehicles and machines can be mitigated include the development of novel technological solutions such as the introduction of lightweight materials, less harmful fuels, controlled fuel combustion, and more effective exhaust gas after treatment. In an internal combustion (IC) engine, the high-pressure gases and high-temperature expansion that arise from burning apply direct force on the components of engine-like pistons. This causes the components to move across a specific distance, so transforming chemical energy into useable mechanical energy. The adequate lubrication of a vehicle's moving components is vital for the reliable and safe functioning of the vehicle under the conditions that are needed for operation. This is done so that the moving components may glide over each other without producing friction. In order to cut down on energy loss, one of the most significant actions to take is to limit the amount of wear and friction that occurs, particularly in engines and drive trains. Mineral oils have a long history of usage as a lubricant in internal combustion engines (IC). Mineral oils, on the other hand, are a byproduct of the distillation of crude oil and can therefore only be utilized for as long as crude oil is in supply. To add insult to injury, mineral oils that are disposed of incorrectly pollute both marine and terrestrial environments. In addition, it has been found that the combustion of mineral oils as a lubricant releases trace quantities of metals such as calcium, phosphorus, zinc, magnesium, and iron nanoparticles. Combustion generates emissions of these metals. Furthermore, the current and future prospects of mineral oils as lubricants in vehicle engines are anticipated to be low, and these prospects are likely to stay unaltered in the future. Consequently, studies are performed to find practical substitutes for the mineral lubricants now utilized in IC engines. Oil from the *prosopis juliflora* plant is ideal for producing bio lubricant. Variables such as the plant's location, environmental conditions, and level of maturity contribute to the wide variation in oil content, from 42-54%. Any bio lubricant manufacturing that 3% in any sort of biodiesel production. Likewise, the transesterification process using base catalyst is unable to

uses an FFA oil concentration of less than 3% has shown that using a catalyst is the most efficient approach for converting the oil. The high FFA content in vegetable oils is also inaccessible to the transesterification process using a base catalyst. Here, we look at the feasibility of using a two-step transesterification procedure to convert pumpkin oil into methyl esters. Several transesterification methods, each with two stages, were performed on each oil sample. These procedures called for a certain amount of methanol and KOH, which were afterwards washed away with water and heated to remove any leftover residues of water. In this experiment, 15 grams of potassium hydroxide (KOH), which works as a catalyst for transesterification, are added to a solution of juliflora seed oil to produce fatty acid. The engine was operated at different loads, from no load to full load, and in an overload state, all while using the mixture specified above with diethyl ether as the additive. The results of the testing revealed a decline in Brake Thermal Efficiency (BTE) and an increase in Specific Fuel Consumption. One of the main benefits of utilizing *Prosopis juliflora* oil is the cheaper cost compared to sunflower oil, soybean oil, and other forms of edible oil. Literature review results indicate that there has not been much experimental investigation of blended bio-lubricants. Diethyl ether, when used as an additive, and *prosopis juliflora* bio lubricant are not yet well characterized in terms of combustion and emission behavior. The proposed research endeavor will focus on the combustibility characteristics of a bio-lubricant extracted from the *prosopis juliflora* plant.

1.2 ITEMS REQUIRED

S.NO	ITEM	QUANTITY
1.	PROSOPIS SEED	6 Kg
2.	PURE PROSIPIS SEED	5Kg
3.	METHANOL	2 Litre
4.	SODIUM HYDROXIDE	20grams
5.	SODIUM LAURYL SULPHATE	500grams
6.	HOT PLATE	1 nos
7.	MAGNETIC STIRRER	1nos
8.	BEAKER (50ML)	2 nos
9.	BEAKER (250ML)	2 nos
10.	MEASURING JAR	1 nos
11.	THERMOMETER	1 nos
12.	FUNNEL	1 nos
13.	GLASS STIRRER ROD	1 nos
14.	FILTER PAPER	20 units
15.	MAGNETIC PELLET	1 nos

1.3 MATERIAL DESCRIPTION

1.3.1 MACHINE EXPELLER



Fig:1.1: Oil Extraction Machine

Oil is extracted mechanically from raw materials using a machine called an expeller (also known as an oil press). In a single process, the raw materials are compressed under intense pressure. Nuts, seeds, and algae are common raw materials used for the extraction of food oils and are continuously fed to the press. Friction from pressing the raw material heats it up; for tougher nuts (which need greater pressures), this heating can reach temperatures of 120 °F (49 °C).

1.3.2 METHANOL



Fig:1.2: Methanol

Methanol was a substance having the chemical formula of CH₃OH. Methanol was previously primarily created by the destructive distillation of wood, thus the term "wood alcohol." Nowadays, industrial methanol production mostly involves hydrogenating carbon monoxide. The simplest alcohol is methanol, which is made up of a methyl

group attached to a hydroxyl group. It is a colourless, flammable liquid that is light and volatile, and its unique odour is comparable to that of ethanol (drinking alcohol). However, methanol is much more hazardous than ethanol. It is a polar liquid when it is at room temperature. It is manufactured in excess of 20 million tonnes yearly and serves as a precursor to a variety of more specialised compounds as well as formaldehyde, acetic acid, and other common molecules like methyl tert-butyl ether.

1.3.3 BEAKER

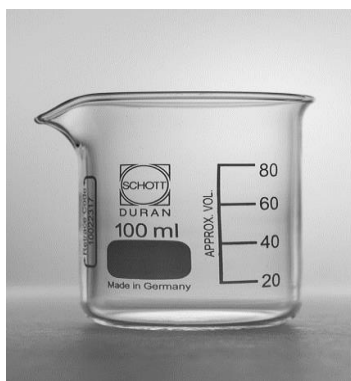


Fig:1.3: Beaker

An ordinary cylindrical container with a flat bottom is referred to as a beaker. In addition, as seen in the image, most include a tiny spout (or "beak") to facilitate pouring. Beakers are available in a variety of sizes, ranging from one millilitre to 5 litres.

1.3.4 MEASURING JAR



Fig:1.4: Measuring Jar

Specifically for amounts from about 50 ml and higher, a measuring cup is a kitchen tool used for measuring the volume of liquid/solid culinary components like flour and sugar. Additionally, liquid detergents, bleach, and washing powder are all measured using measuring cups. The cup often has a scale with markings in cups, as well as fluid measurements and the weight of a variety of dry items.

1.3.5 THERMOMETER



Fig:1.5: Thermometer

An instrument known as a thermometer is used to measure temperature or a temperature gradient. There are two crucial components to a thermometer:

A temperature sensor that changes in response to changes in temperature, such as the bulb of a mercury-in-glass thermometer / infrared thermometers.

A technique for turning this change to a number. In technology and industry, as well as in meteorology, health, and scientific study, thermometers are frequently used to monitor operations.

1.3.6 GLASS STIRRING ROD



Fig:1.6: Glass Stirring Rod

A glass stirring rod, sometimes known as a glass rod, a stirring rod, or simply a stir rod, is a piece of scientific apparatus used to combine chemicals and liquids for testing reasons. Typically, they are constructed of solid glass, about the same thickness and length as a drinking straw, and have rounded ends.

1.3.7 TEST TUBE



Fig:1.7: Test Tube

A test tube, also called a sample tube, is a typical item of lab equipment made of a finger-like length of clear plastic or glass tubing that is open at the top and closed at the bottom.

1.3.8 STIR BAR OR MAGNETIC PELLETT



Fig:1.8: Stir bar or magnetic Pellet

The magnetic bar that is inserted into the liquid to stir it is known as a stir bar. Another revolving magnet or electromagnet assembly in the stirrer, underneath the vessel carrying the liquid product, is what moves the stir bar. Stir capsules are frequently coated with PTFE or with glass; these coatings are meant to be chemically inert so they won't contaminate or interact with the reaction mixture they are in. Alkali metal solutions in ammonia and liquid alkali metals are both protected by glass coatings (except from lye, which will eat through glass).

Although there are many other specific designs for more effective stirring, they are typically bar-shaped and have an octagonal (or occasionally circular) cross-section. The majority of stir bars spin around a pivot ring in the centre. The biggest are only a few centimetres long, while the tiniest are barely a few millimetres. Stir bars can be removed from a vessel using a stir bar retriever, which is a separate magnet on the end of a long stick (often coated with PTFE).

1.3.9 HOT PLATE



Fig: 1.9: Hot Plate

Hot plates are typically used in laboratories to warm glassware or its contents. Some hot plates also come with a magnetic stirrer that automatically stirs the heated liquid.

Because baths have a high thermal inertia (i.e., they take a long time to cool down), they can be dangerous if they spill, overheat, or burn, and mantles can be costly and made for certain flask capacities, hot plates are utilised in student laboratories instead of baths.

There are two other ways to use a hotplate to warm glasses. Glassware may be placed on a plate by suspending it just slightly above the surface without making direct contact. In addition to lowering the glass's temperature, this also promotes even heating by slowing the rate of heat exchange. This is effective when a heat source's minimum temperature is high or for procedures with low boiling points. Another technique involves suspending glasses over a plate and enclosing the flask with a skirt of tinfoil. This configuration is known as a "tepee setup" since it somewhat resembles a tipi.

The skirt should begin at the flask's neck and fall to the plate's surface, covering the bulk of the plate's surface but not touching the flask's sides. Unlike just dangling the glassware, this approach is more shielded from draughts and allows for the heating of glassware at greater temperatures since the flask is indirectly warmed by the hot air gathering under the skirt.

1.3.10 SODIUM HYDROXIDE (NaOH)



Fig: 1.10: Sodium Hydroxide

In normal atm temperatures, sodium hydroxide, a highly caustic base and alkali, breaks down proteins and it will result in serious injuries like chemical burns. It will easily collect moisture and CO₂ from the air due to its high water solubility. It produces a string of NaOH hydrates.

1.3.11 WEIGHING SCALE



Fig: 1.11: Weighing Scale

A weighing scale, often known as a weighing balance, is a tool used to determine mass or weight. These can also be referred to as mass scales, weight scales, scales, or balancing scales.

The conventional scale is made up of two plates or bowls hanging from a fulcrum at equal intervals. While measured masses are added to the other plate, one is holding an object with an unknown mass (or weight), and this process continues until static equilibrium is reached and the plates equal off, which occurs when the masses on the two plates are equal. A spring scale uses a spring with known stiffness to calculate mass (or weight). Depending on the spring's stiffness, suspending a specific mass causes the spring to stretch by a specific amount (or spring constant). According to Hooke's law, the spring extends more the heavier the item is. There are other scales as well, using other physical concepts.

Some scales may be calibrated to read in weight (force) units like newtons rather than mass ones like kilogrammes. As many things are mass-produced and marketed, scales and balances are frequently employed in business.

1.3.12 FILTER PAPER



Fig: 1.12: Filter Paper

A semi-permeable paper is called as filter paper and which is positioned perpendicular to a liquid or air flow. Fine materials are separated from liquids or air using this method. In scientific labs, it is used to separate solids from liquids. Sand may be removed from water using this technique.

1.3.13 DATA ACQUISITION SYSTEM

Rotational speed, wear, temperature, and the number of rotations are all collected by WINDUCOM2010. Additionally provided are friction force, sliding speed, sliding distance, and test time. The ability to show the data in various ways is made possible

by the data acquisition system. With the help of the Compari-View module, graphs for individual tests may be printed, and the results up to 4(four) tests can be overlaid for comparison. Data may be exported in ASCII format to other programmes like MS-Excel.

1.3.14 MAGNETIC STIRRER



Fig: 1.13: Magnetic Stirrer

A revolving magnetic field is produced by a magnetic stirrer. A tiny bar magnet and a platform or plate that houses the revolving magnet are included in the design of the magnetic stirrer.

The spinning magnet is located on a plate, and the bar magnet is often covered with plastic. With the aid of a revolving magnet, it is feasible to produce a rotating magnetic field.

CHAPTER 2

2. 1 LITERATURE SURVEY

2.1.1 Don M. Pirro; Martin Webster; Ekkehard Daschner (2016). Lubrication Fundamentals (Third Edition, Revised and Expanded ed.). CRC Press. ISBN 978-1-4987-5290-9. (print) ISBN 978-1-4987-5291-6. There are many different uses for lubricants, including in the manufacturing sector, the kitchen (oils and fats are used to prevent food from sticking in frying pans and baking), biomedical applications on people (such as lubricants for artificial joints), ultrasound examination, and medical examinations

2.1.2 Thorsten Bartels et al. "Lubricants and Lubrication" in Ullmann's Encyclopedia of Industrial Chemistry, 2005, Weinheim. doi:10.1002/14356007.a15_423 The use of lubricants may be traced back thousands of years; calcium soaps, for instance, have been found on the wheels of chariots from 1400 BC. During the time of the Romans, lubricants were made from a variety of oils, including rapeseed oil, olive oil & animal fat. In the early 1900s, many materials derived from petroleum were produced. The invention of the vacuum distillation of petroleum marked a significant advancement in the field.

2.1.3 Owuna, F.J.; Dabai, M.U.; Sokoto, M.A.; Dangoggo, S.M.; Bagudo, B.U.; Birnin-Yauri, U.A.; Hassan, L.G.; Sada, I.; Abubakar, A.L.; Jibrin, M.S. Chemical modification of vegetable oils for the production of biolubricants using trimethylolpropane: A review. Egyptian Journal of Petroleum 2020, 29, 75-82, <https://doi.org/10.1016/j.ejpe.2019.11.004> In order to create goods that are less harmful to the environment, the use of renewable raw resources is becoming more important. As the trend advances toward more eco-friendly goods, there has been a rise in the use of oils and fats derived from both plant and animal sources. It provides a huge variety of opportunities for applications, most of which cannot be satisfied by petrochemical resources. Lubricants are crucial to the operation of almost every component of contemporary equipment.

2.1.4 Owuna, F.J. Stability of vegetable based oils used in the formulation of ecofriendly lubricants – A review. Egyptian Journal of Petroleum 2020, 29, 251-256, <https://doi.org/10.1016/j.ejpe.2020.09.003>

Lubricants are chemicals that are used to lubricate surfaces that are in mutual contact in order to ease the movement of components, minimise friction, and extend the life of moving parts. When sustainability became a driving force in the business, conserving energy and resources, as well as reducing emissions, became fundamental environmental concerns. As a result, the business world places a special emphasis not only on the limited availability of resources but also on its obligation toward future generations.

2.1.5 Lourenço, S.C.; Moldão-Martins, M.; Alves, V.D. Antioxidants of natural plant origins: From sources to food industry applications. Molecules 2019, 24, 4132, <https://doi.org/10.3390/molecules24224132>.

Because they contribute to the achievement of sustainability goals in the economic, ecological, and social spheres, lubricants are gaining a growing amount of public attention. Lubricants are important to the efficient use of resources and, as a result, to the concept of sustainability.

2.1.6 Afida, S.; Ghazali, R.; Yeong, S.; Hassan, H. Biodegradability of palm-based lubricants. 2015, 27, 425-432.

Lubricants provide a significant contribution to the efficient use of resources, and as a result, to sustainability. Increasing the longevity of equipment and the components of that machinery, as well as improving their efficiency and dependability, may be accomplished by using a lubricant that is optimally suited to the application.

2.1.7 Cecilia, J.A.; Ballesteros Plata, D.; Alves Saboya, R.M.; Tavares de Luna, F.M.; Cavalcante, C.L.; RodríguezCastellón, E. An Overview of the Biolubricant Production Process: Challenges and Future Perspectives. Processes 2020, 8, 257, <https://doi.org/10.3390/pr8030257>.

A significant fraction of the lubricants that are used all over the globe ultimately contribute to environmental pollution. A great deal of work is put into reducing the amount of evaporation and spillage. The significant amount of oil that is lost into the environment was the driving force behind the creation of lubricants that are favourable to the environment.

2.1.8 Salimon J, Salih N. Chemical modification of oleic acid oil for biolubricant industrial applications. Aust J Basic Appl Sci 2010;4:1999–2003. It is impossible for the whole globe to convert over to bio-based lubricants all at once; rather, this transition must take place in stages and need the cooperation of several sectors, including agriculture, industry, research, and the government. Lubricants made from vegetable oils that have been chemically and genetically changed have a great potential to carry out their functions correctly. Now, with rising prices for petroleum, falling reserves of petroleum, and growing worries about the environment as important causes, the use of vegetable oils as lubricants is making a gradual but steady return.

2.1.9 Jain A, Suhane A. Research approach & prospects of non edible vegetable oil as a potential resource for biolubricant-a review. Adv Eng Appl Sci Int J 2012;1:23–32. In comparison to lubricants that are derived from petroleum, vegetable oils, in general, have higher flash points, better viscosity indices, greater lubricity, lower evaporative losses, and superior metal adhesion. Because of the combination of a polar group and a long hydrocarbon chain, vegetable oil has the inherent property of being an amphiphilic surfactant. This property gives vegetable oil the ability to function as a boundary lubricant.

2.1.10 Srivastava A, Sahai P. Vegetable oils as lube basestocks: a review. Afr J Biotechnol 2013;12:880–91. <http://dx.doi.org/10.5897/AJB12.2823> Farmers' salaries may experience a rise, and more of a variety of agricultural goods could be put to use, if more markets were developed for less common seeds and oils. Vegetable oils are beneficial for the environment since they are naturally biodegradable, have minimal toxicity for both people and the environment, and come from renewable resources. Vegetable oils also have low ecotoxicity and low toxicity overall.

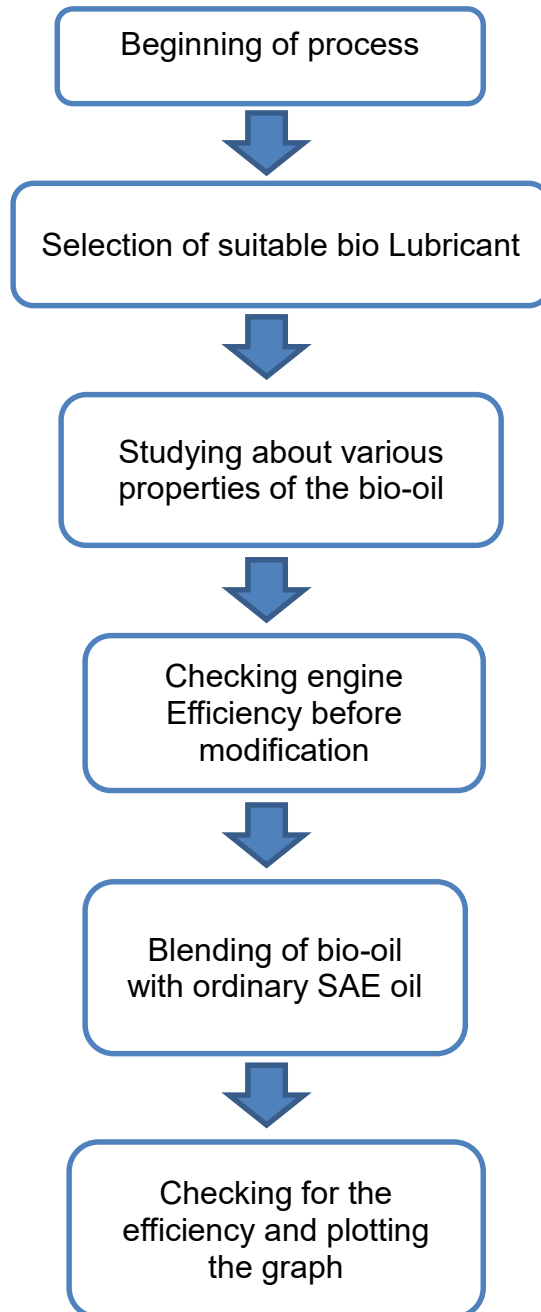
CHAPTER 3

3.1 AIM AND OBJECTIVE OF THE PRESENT INVESTIGATION

3.1.1 AIM AND OBJECTIVE

- Evaluation of Four-Stroke Diesel Engine Efficiency.
- Find out whether any Prosopis juliflora seed oil is on sale and learn about its qualities.
- Adding bio-lubricant, such as Prosopis seed oil, to straight SAE OIL at varying concentrations of 10% and 20%.
- Testing the efficiency of DI (Direct Injection) diesel engines using biodiesel mixes in the laboratory.
- Examining the differences between using 100% diesel and different biodiesel mixes in a DI diesel engine under varying loads.
- SAE Oil vs Bio-Lubricant Blends Under Full Load Performance and Emissions Testing

3.1.2 METHODOLOGY



CHAPTER 4

4.1 NECESSITY FOR IMPROVING ENGINE PERFORMANCE

Due to its higher power per unit of fuel and reduced volatility, diesel is used in the majority of industrial industries and is safer to handle. The potential to completely stop using petroleum is one particularly appealing advantage of diesel versus gasoline. Modern ships, trains for long-distance, large-scale portable power generators, trucks / buses, agriculture, mining equipment, and other heavy-duty vehicles all feature diesel engines. Heavy duty vehicles used in the transportation and agriculture industries are propelled mostly by diesel engines. Today, diesel engines are utilised to generate the majority of the world's electricity, therefore enhancing their performance is crucial.

4.2 THEORETICAL STUDY OF EXPERIMENTAL SETUP

4.2.1 STROKE DIESEL ENGINE:

A diesel engine commonly referred as an internal combustion engine that ignites gasoline pumped inside the combustion chamber using the heat of compression. Spark-ignition engines employ a spark plug to ignite an air-fuel mixture, such as a gasoline engine or a gas engine (which uses a gaseous fuel instead of gasoline). German inventor Rudolf Diesel created the engine in 1893.

Due to its extremely high ratio of compression, the diesel engine has the highest thermal efficiency of any ordinary internal combustion engine. The thermal efficiency of slow-speed diesel engines, which are typically employed in ships and other applications where overall engine weight is less of a factor, can be greater than 50%. Both four-stroke and two-stroke diesel engines are produced. They were initially employed to replace stationary steam engines with ones that were more effective. They have been utilised in ships and submarines since the 1910s. Later came use in trucks, heavy machinery, trains, and electric generating stations. They gradually started to appear in a few cars in the 1930s. Larger on-road and off-road vehicles have increasingly used diesel engines in the USA since the 1970s. Around 50% of new automobile sales in Europe as of 2007 were diesels.

4.2.2 CONSTANT PRESSURE CYCLE:

Instead of using a spark plug to ignite the fuel, the diesel internal combustion engine uses highly compressed hot air, which is how it differs from the gasoline-powered Otto cycle (compression ignition rather than spark ignition).

In a real diesel engine, the combustion chamber is initially filled exclusively with air. The air is then compressed at a ratio of 15:1 to 22:1, generally, to produce a pressure of 40 bar (4.0 MPa; 580 psi), as opposed to 8 to 14 bars (0.80 to 1.4 MPa) (about 200 psi) in the gasoline engine. The air is heated by the high compression to 550 °C (1,022 °F). Direct injection of fuel into the combustion chamber's compressed air occurs at or near the peak of the compression stroke. Depending on the engine's architecture, this may go into the piston's upper void or a pre-chamber.

The fuel injector makes sure that the gasoline is uniformly dispersed and is broken down into little droplets. Fuel from the surface of the droplets is vaporised by the heat of the compressed air. The droplets continue to evaporate off their surfaces and burn, increasing smaller, until all the fuel in the droplets has been burned. The vapour is then ignited by the heat from the compressed air in the combustion chamber. As the vapour approaches ignition temperature and creates a rapid increase in pressure above the piston, vaporisation begins, delaying the ignition process and producing the distinctive diesel knocking sound. The piston is then driven downward as a result of the combustion gases' quick expansion, powering the crankshaft.

A high compression ratio considerably improves the engine's efficiency in addition to enabling combustion to occur without the use of a separate ignition system.

4.3 DESCRIPTION ABOUT COMPONENTS:

- Diesel Engine
- U-Tube Manometer
- Data Acquisition System
- Load System
- Generator
- Fuel Tank
- Pressure gauge

- Bio-Diesel
- Measuring jar
- voltage regulator
- Exhaust Gas Analyzer

4.3.1 DIESEL ENGINE:

A diesel engine, commonly referred to as a compression-ignition engine, is an internal combustion engine that ignites gasoline pumped into the combustion chamber using the heat of compression. Spark-ignition engines employ a spark plug to ignite an fuel-air combination, such as a petrol engine or a gas engine (which uses a gaseous fuel instead of gasoline). German inventor Rudolf Diesel created the engine in 1893.

Due to its extremely ratio of high compression, the diesel engine has the best thermal efficiency of any ordinary internal or external combustion engine. Low-speed diesel engines can have a thermal efficiency of more than 50% (as used in ships and other applications where total engine weight is very unimportant).



Fig: 4.1: Diesel engine

4.3.2 SPECIFICATION OF DIESEL ENGINE:

Engine Details:

Kirloskar TV1, a single-cylinder, four-stroke, constant speed, water-cooled, diesel engine with cylinder bore and stroke measurements of 87.50 mm, 110.00 mm, 234.00 mm, a compression ratio of 17.50, and a swept volume of 661.45 mm, is the ICEngine setup being tested. It has a power output of 5.20 kW at 1500 rpm (cc).

Combustion Parameters:

Air density (kg/m³): 1.171, specific gas constant (kJ/kgK): 1.0, Adiabatic index is 1.410, polytropic index is 1.24, there are 5 cycles, 3 cycles of cylinder pressure reference, 2 cycles of smoothing reference, and 0 cycles of TDC reference.

Performance Parameters:

Dynamometer arm length (mm): 185, Orifice Diameter (mm): 20.00, Orifice Coefficient of Discharge: 0.60 Fuel pipe diameter (mm), ambient temperature (deg C), 360 pulses per rotation, and 12.40 mm Diesel fuel type, 855 kg/m³ fuel density Fuel's Calorific Value (kJ/kg): 43638

4.3.3 DATA ACQUISITION SYSTEM:

The process of sampling signals that measure actual physical conditions and transforming the resulting samples into digital numeric values that a computer can manipulate is known as data acquisition system. Analog waveforms are often converted into digital values by data acquisition systems (DAS or DAQ) for processing. The following are some of the data acquisition systems' parts: electrical signals from physical factors using sensors.

Circuitry that conditions sensor signals so they may be translated to digital values using analog~digital converters.

Transesterification Procedure

A 500 mL glass spherical reactor built with a thermostat, mechanical mixing, a sampling point, and a condensation apparatus was used to conduct the transesterification processes. The process that was used is then outlined. To remove moisture, the reactor was warmed to 75 °C. Next, 250 g of each *Prosopis Juliflora*

seed oil and eucalyptus oil were added. The methanol and catalyst were introduced to the reactor at the predetermined temperature for the reaction, in the amounts determined for each experiment, we refer to this period as reaction time zero.

For the necessary reaction period, each mixture was refluxed while being agitated ferociously. Excess ethanol was then vacuum-distilled off when the methanolysis process was complete (absolute pressure of 150 mmHg). The transesterification reaction product was allowed to stand in a separating funnel for glycerol separation. Gravity alone was unable to separate glycerol from the ethyl ester phase, thus 10 gram of 99.9% glycerol were added to the esterification reaction mixture, the separating funnel was violently agitated, and the product was left to stand. This assisted in separating the ethyl ester phase from the glycerol phase. Within an hour, the ester layer and glycerol layer split apart. When pure glycerol is added to the mixes, the soaps and remaining catalyst from the transesterification reaction are eliminated. This results in a difference in the densities of the two phases, which makes gravity separation of the two phases simpler.

After the two layers were separated, 50 cm³ of hot distilled water (50 °C) was used to wash the crude methyl esters many times (up to ten times) until the pH was neutral. At 110 °C, the remaining water was finally destroyed.



Fig: 4.2: ProsopisJuliflora seed oil – blend with Equalypytus

4.3.4 EXPERIMENTAL WORKS

Emulsions are tested in the Kirloskar TAF single cylinder, air cooled, four-stroke, direct injection diesel engine once they have been created.

The engine setup consists of an alternator and a single-cylinder, four-stroke engine (1). (2). The load cell regulates the load, which will trigger the alternator to put pressure on the engine. The air box draws in air, which then passes through an air flow sensor that calculates how much air is being drawn in. A fuel sensor is used to detect fuel data. These measurements are sent to the data collecting system as inputs. The emissions from exhaust pipes are measured using an AVL 444 gas analyzer.



Fig: 4.3: Testing machine



Fig: 4.4: Smoke meter



Fig: 4.5: Gas Analyser



Fig: 4.6: Dynamometer

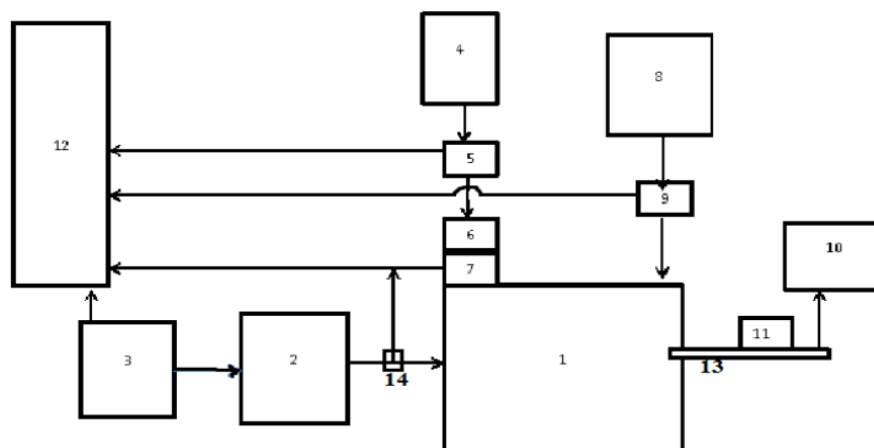


Fig: 4.7: Schematic Diagram of engine Setup

1. engine	2.alternator	3. load cell with control panel
4. Fuel tank	5. fuel sensor	6.fuel filter
7.fuel pump	8. Air box and air filter	9. Air flow sensor
10. Gas analyzer	11. Thermocouple	12.Computerised data acquisition system
13. exhaust pipe	14. speed sensor	

4.4 TYPES:

You may choose from a number of different types of magnetic stirrers, depending on the size, use, and configuration.

Below is a list of the numerous types:

4.4.1 Magnetic Mini Stirrer:

The micro magnetic stirrer is, as its name implies, a small-sized stirrer that takes up very little room and enables users to precisely manage the speed with the aid of the controls offered. It has been cleverly made to withstand the toxic chemicals found in a laboratory setting. Additionally, it includes a speed regulator to make sure the machine will never exceed the max. speed.

4.4.2 Magnetic Stirrer With Timer:

The name again tells it all. This particular stirrer has the capacity to automatically turn off the motor after a certain period of time. This operates by using an internal timer to turn off the stirrer once the pre-selected amount of time has passed. Additionally, the speed is automatically decreased, and the weight is automatically taken away

4.4.3 Heavy Duty Magnetic Stirrer:

As mentioned, the heavy-duty magnetic stirrers work well. In addition to being extremely robust and having a higher chemical resistance, they also have a high mixing capacity. They also include an inbuilt electronic control system that automatically adjusts the speed according on the load. As a result, the heavy-duty magnetic stirrer is the ideal tool for use in a lab or industrial setting.

4.4.4 Battery Powered Magnetic Stirrer:

Where there isn't an electrical outlet, the battery-powered magnetic stirrer is useful. They are mostly used in incubators. They have rubber feet, and the included speed control knobs may be used to adjust their speed. Although rechargeable batteries should function just fine, alkaline batteries may generally be utilised with these gadgets.

4.4.5 Air Operated Turbine Magnetic Stirrer:

The air operated turbine separator is the best piece of equipment if you need to stir up to one litre of liquid. The main benefit is that it does away with the dangers brought on by electrical sources sparking.

4.5 WORKING:

A tiny magnetic bar is inserted into the mixture being stirred by magnetic stirrers, and an external magnetic field is given to it to make it easier for the bar to rotate. The magnetic field's fast rotation causes the bar magnet to revolve, churning the liquid as a result. In laboratory investigations, their typically tiny sizes are greatly sought.

4.6 FUNCTIONS AND USES

The magnetic-stirrers, which are also known as magnetic-stir plates, are frequently used for chemical and biology investigations. They come in particularly handy when you need to combine ingredients—liquids or solids—to produce a uniform liquid combination. The most typical samples are buffer solutions and bacterial growth medium. • The basic purpose of a stirrer is to stir the liquid in order to speed up reactions or improve mixes. Hot plates are frequently used with a magnetic stirrer.

4.7 BENEFITS:

Since just an inert magnet bar is inserted into the sample, one of the main benefits of a magnetic stirrer is that it reduces the danger of contamination (fluid). Additionally, this is simple to clean. A magnetic stirrer is necessary for repeatable mixing or combining over a lengthy period of time since a manual stirrer is not as reliable as a magnetic one. For instance, protein dialysis needs samples to be mixed for many hours or overnight and is susceptible to bacterial contamination.

4.8 SPECIFICATIONS:

- There are several varieties of magnetic stirrers.
- The I Stir Uno Magnetic Stirrer's specs may be seen below.
- This one requires no maintenance and has no moving components.

- It features a customizable speed and a software-driven progressive acceleration.
- It is microprocessor-controlled and has the capacity to store the last run's memory.

Basic Specifications:

- Max RPM – 1500 RPM
- Speed Setting – 15 to 1500 RPM
- Speed Indicator
- Load Capacity – 800 ml
- Recommended Stir bar length – 25 mm
- Pulse function
- Sync mode
- Last run memory
- Dimensions (W x D X H) – 125 x 165 x 12 mm
- Weight – 400 gms
- Protection Class – IP65 compliant design (Water Spill resistant).

4.9 PROSOPIS SEED OIL

- Prosopis seed oil is a kind of vegetable oil made from the fruits and seeds of the prosopis seed (*Azadirachta indica*), an evergreen tree native to the Indian subcontinent but now found in many other tropical regions. Commercially accessible prosopis seed products for organic farming and pharmaceuticals do not include this oil.
- The colour of prosopis seed oil varies; it might be brilliant red, greenish brown, golden yellow, dark brown and (or) yellowish brown. It has a rather strong aroma that is claimed to mix the flavours of garlic and peanuts. It is mostly made up of triglycerides and is rich in triterpenoid chemicals, which give it its bitter flavour. It is hydrophobic by nature, but it is prepared with surfactants so that it may be emulsified in water for application purposes.
- The triterpene most widely recognised and researched in prosopis seed oil is azadirachtin. Another triterpenoid called nimbin is thought to be responsible

for part of prosopis seed oil's antibacterial, antifungal, antipyretic, and antihistamine activities. Additional sterols found in prosopis seed oil include campesterol, beta-sitosterol, and stigmasterol.

- Since the processes utilised, pressing (expelling) / solvent extraction, are unlikely to remove exactly the same mix of components in the sample, they are likely to have an impact on the composition of the oil. Additionally, the literature shows a broad range of prosopis seed oil yields from prosopis seed seed kernels, ranging from 25% to 44%.
- The oil can be produced by pressing (crushing) the seed kernel at either a low temperature, such as cold pressing, or at a higher temperature, such as 40 to 50 °C. Prosopis seed fruit, oil, cake, or kernel solvent extraction can also be used to get prosopis seed seed oil. Hexane is used by a sizable business in India to extract the leftover oil from the seed cake. When compared to cold-pressed oil, this obtained oil is of poor in quality and is mostly used to make soap. A co-product of the solvent extraction method used to get prosopis seed oil is prosopis seed cake.

4.10 U-TUBE MANOMETER

A manometer could also refer to a pressure measuring instrument, usually limited to measuring pressures near to atmospheric. The term manometer is often used to refer specifically to liquid column hydrostatic instruments. In this project ac motor is used.

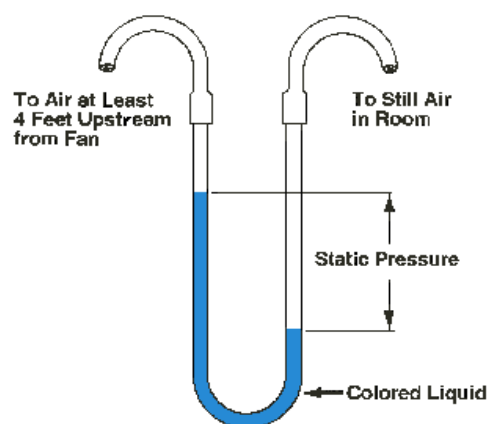


Fig: 4.8: U-Tube manometer

4.11 DATA ACQUISITION SYSTEM

- The process of sampling signals that gauge actual physical circumstances and transforming the resulting samples into digital numeric values that a computer can manipulate is known as data acquisition. Analog waveforms are often converted into digital values by data acquisition systems (abbreviated as DAS or DAQ) for processing. Sensors that translate physical properties into electrical signals are a part of data acquisition systems.
- Circuitry for signal conditioning that transforms sensor signals into forms that can be translated into digital values.
- Analog-to-digital converters, which transform sensor signals into digital values after conditioning.

4.12 LOAD SYSTEM

A load bank is an apparatus that creates an electrical load, connects it to an electrical power source, and then transforms or dissipates the source's output power.

A load bank's objective is to faithfully simulate the operational or "real" load that a power source would experience in practical use. However, a load bank offers a controlled, ordered, and completely controllable load, in contrast to the "actual" load, which is more likely to be distributed, unpredictable, and random in value.

As a result, another definition of a load bank is a self-contained, unitized, systematic device that has load components as well as the control and ancillary devices needed to operate.

In contrast to the "actual" load, which utilises the power source's energy output for some productive purpose, the power source is served by the load bank, which uses its energy output to test, support, or safeguard the power source.

4.13 GENERATOR AND SPECIFICATIONS

An electric generator is a machine used to produce electricity that transforms mechanical energy into electrical energy. Electric current is forced via an external circuit by a generator. A reciprocating or turbine steam engine, water passing through a turbine or waterwheel, an internal combustion engine, a

wind turbine, a hand crank, compressed air, or any other source of mechanical energy can be used as the source of mechanical energy. Electric power grids are powered almost entirely by generators.

An electric motor, which has many characteristics with generators, converts electrical energy back into mechanical energy. It is possible to mechanically operate a variety of motors, which typically function well as generators.

Specifications:

- KIROGEN A.C GENERATOR
- Model = KBM-104
- Output = 4 kVA
- Volts = 230V
- Amps = 17.4
- Frequency = 50 Hz
- Speed = 1500 rpm

4.14 FUEL TANK AND SPECIFICATIONS

A safe container for flammable liquids is a fuel tank (or diesel tank). Though any gasoline storage tank may be referred to as such, the phrase is commonly used to refer to a component of an engine system where fuel is kept and either released (through pressured gas) or driven (via a fuel pump) into an engine. From the little plastic tank of a butane lighter to the multi-chambered cryogenic Space Shuttle external tank, fuel tanks differ in size and complexity.



Fig: 4.9: Fuel Tank

Specifications:

- Capacity = 5 lit
- Type = cylindrical type
- Material = G.I sheet (alloy sheet)

4.15 PRESSURE GAUGE

Fig: 4.10: Pressure Gauge

Jatropha curcas is a toxic shrub-like tree that produces seeds that are thought by many to be a potential source of biodiesel feedstock oil. Several organisations in various industries are researching this plant. The goal of much of this study is to increase Jatropha's total oil output per acre through improvements in genetics, soil science, and horticulture techniques.

4.16 MEASURING JAR

A measuring cup or jug is a kitchen tool that is generally used to measure the volume of liquid or bulk solid culinary materials like flour and sugar, especially for quantities from around 50 mL upwards. Typically, the cup will contain a scale marked in cups and fractions of a cup, as well as a fluid measure and the weight of a number of different dry goods. When using a measuring cup that is not also used for food, you can measure bleach, liquid detergents, or washing powder.



Fig: 4.11: Measuring Jar

4.17 VOLTAGE REGULATOR

- It is intended to automatically keep the voltage level constant. A voltage regulator might have a straightforward "feed-forward" architecture or it can have control loops with negative feedback. It could make use of electrical parts or an electromechanical mechanism. It may be used to control one or more AC or DC voltages depending on the design.
- Voltage regulators (Electronic) regulate the Direct Current (DC) voltages utilised by the CPU & various components in devices like personal computer power supply. This manages the plant's output in a central power plant alternator & automotive alternator. This can be installed along distribution lines in an electric power distribution system or at a substation to ensure that all customers receive a constant voltage regardless of how much power is consumed from the line.

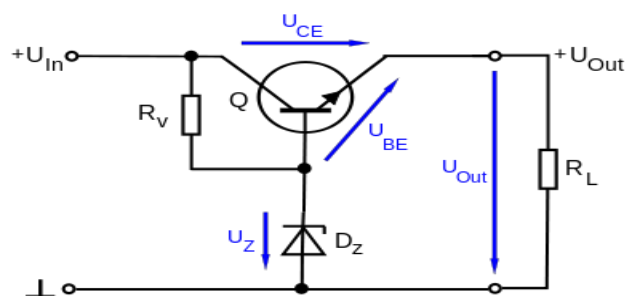


Fig:4.12: Voltage Regulator

CHAPTER 5

5.1 EXPERIMENTAL RESULTS AND DISCUSSIONS

5.2 FORMULA USED

5.2.1 INDICATED POWER:

Power developed inside the engine cylinder by burning the fuel

$$IP = FP + BP$$

Where,

IP	-	Indicated power, kW
FP	-	Friction power, kW
BP	-	Brake power, kW

5.2.2 BRAKE POWER:

Power available at the engine shaft.

$$BP = V \times I$$

Where,

V	-	Voltage, Volts
I	-	Current, Amps
η_{gen}	-	Generator efficiency, %

✓ If the efficiency of generator is considered

$$BP = \frac{V \times I}{\eta_{\text{gen}}}$$

5.2.3 FRICTION POWER

$$FP = IP - BP$$

IP	-	Indicated power, kW
FP	-	Friction power, kW
BP	-	Brake power, Kw

5.2.4 EFFECTIVE PRESSURES

5.2.5 INDICATED MEAN EFFECTIVE PRESSURE

$$P_{im} = \frac{60 \times 1000}{LAnK} \times IP$$

Where,

L	-	Length of stroke, m
A	-	Area of cylinder (C/S)
n	-	N/2 for 4-stroke
K	-	Number of cylinders

5.2.6 BRAKE MEAN EFFECTIVE PRESSURE:

$$P_{bm} = \frac{60 \times 1000}{LAnK} \times BP$$

5.2.7 EFFICIENCIES:

I. INDICATED THERMAL EFFICIENCY

$$\eta_{ith} = \frac{\text{Indicated Power}}{\text{Mass of fuel} \times \text{Calorific value}}$$

II. BREAKTHERMAL EFFICIENCY

$$\eta_{ith} = \frac{\text{Brake power}}{\text{mass of fuel} \times \text{calorific value}}$$

III. MECHANICAL EFFICIENCY

$$\eta_{mech} = \frac{\text{Brake power}}{\text{Indicated power}}$$

IV. VOLUMETRIC EFFICIENCY

$$\eta_{vol} = \frac{\text{Actual volume flow rate}}{\text{Theoretical volume flow rate}}$$

$$q_{act} = \frac{\pi}{4} \times d^2 \times \sqrt{2gh}$$

$$q_{act} \rightarrow \text{actual mass flow rate } \frac{m^2}{s}$$

$d \rightarrow$ diameter of orifice, m

$g \rightarrow$ acceleration due to gravity, $\frac{m}{s^2}$

$h \rightarrow$ head, m

$$Q_{act} = \frac{LAn}{60}, \quad n = \frac{N}{2}$$

V. SPECIFIC FUEL CONSUMPTION (SFC), $\frac{kg}{kW-h}$

$$SFC = \frac{\text{Total fuel consumption}}{\text{Brake power}}$$

VI. TOTAL FUEL CONSUMPTION (TFC)

$$TFC = \frac{10}{t} \times \text{Specific gravity} \times 3.6, \quad kg/hr$$

VII. HEAT ENERGY WASTED IN WATER (COOLANT)

$$H_w = m_w \times c_p \times (T_2 - T_1)$$

$T_2 \rightarrow$ water outlet temperature $^{\circ}C$

$T_1 \rightarrow$ water inlet temperature $^{\circ}C$

$m_w =$ water flow rate, Kg/s

VIII. HEAT ENERGY WASTED IN EXHAUST

$$H_E = (\dot{m}_f + Q_{act}) \times c_p \times (T_2 - T_1)$$

IX. UNACCOUNTED HEAT LOSS

$$H_{acc} = \text{Total heat energy} - \text{heat utilized} - \text{heat to water} - \text{heat to exhaust}$$

X. AIR-FUEL RATIO

$$\text{Air Fuel Ratio} = \frac{\text{Air flow rate}}{\text{Fuel consumption rate}}$$

$$\text{Air Fuel Ratio} = \frac{Q_{act}}{\dot{m}_f}$$

5.3 CHEMICAL TEST RESULT

Table: 5.1: Engine Test Results

PROPERTY	Conventional SAE 20 W 40 OIL	10% with ProsopisJuliflora seed Oil	15% with ProsopisJuliflora seed Oil	25% with ProsopisJuliflora seed Oil
Flash point °C	204	156	190	169
Fire point °C	209	165	180	176
Viscosity at 40 °C	5	8	10	9
Calorific value (MJ/Kg)	44.34	42.5	41.50	41.89
Density at 40 °C (Kg/m3)	885	889	920	902

5.4 COMBUSTION RESULT

10% OF PROSOPIS JULIFLORA SEED Bio Lubricant

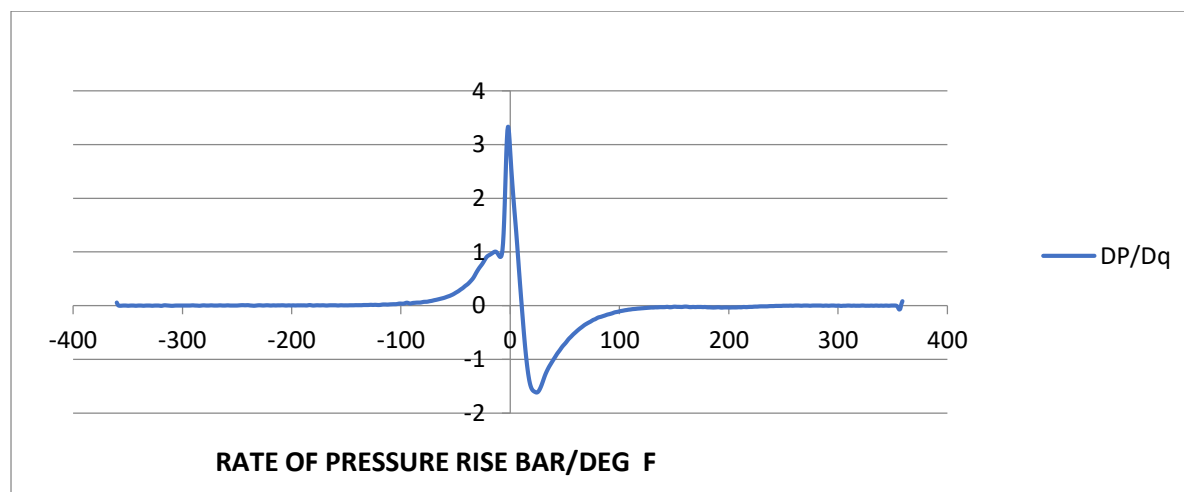


Fig: 5.1: Rate of Pressure Rise Bar/Deg F

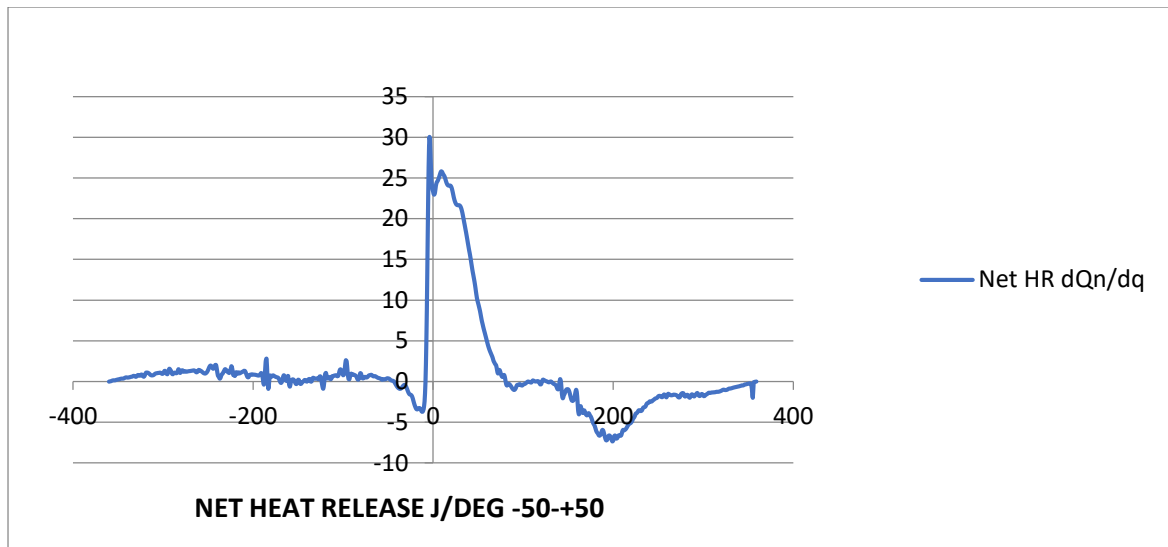


Fig: 5.2: Net Heat Release J/Deg

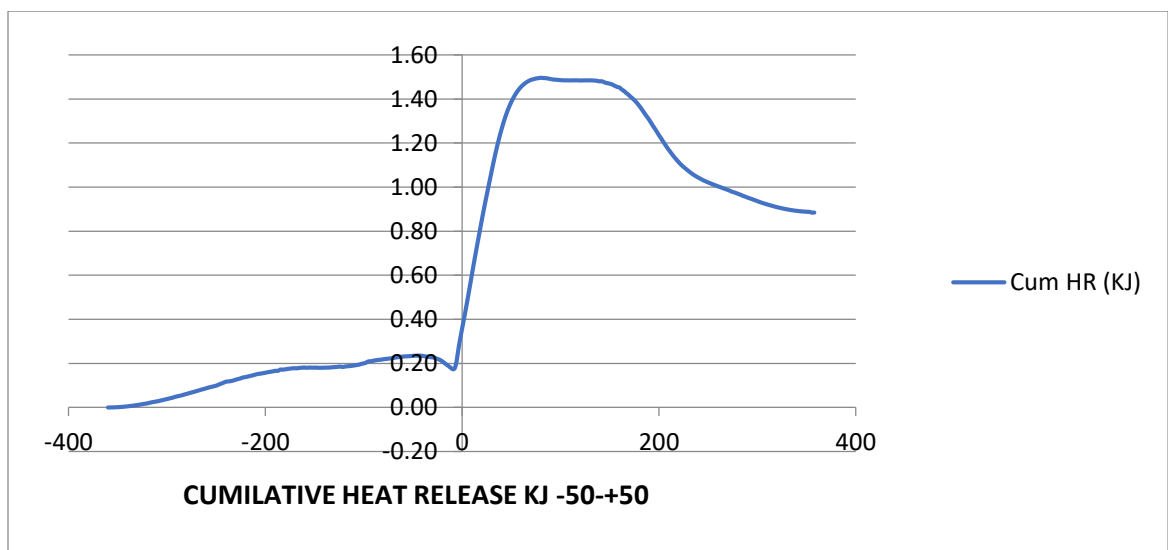


Fig: 5.3: Cumulative Heat Release KJ

15% OF PROSOPIS SEED OIL WITH LUBRICANT

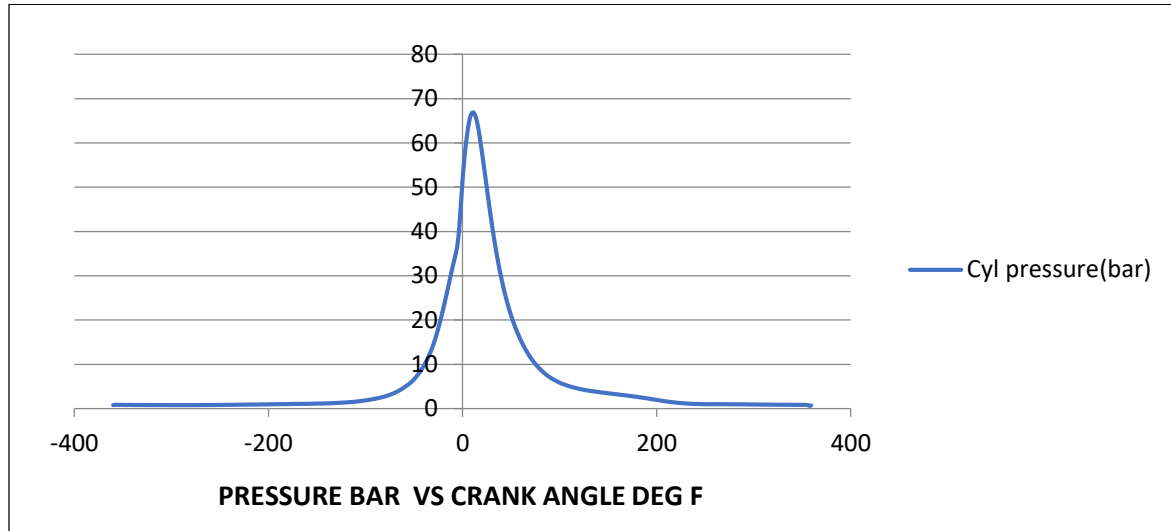


Fig: 5.4: Pressure Bar Vs Crank Angle Deg. F

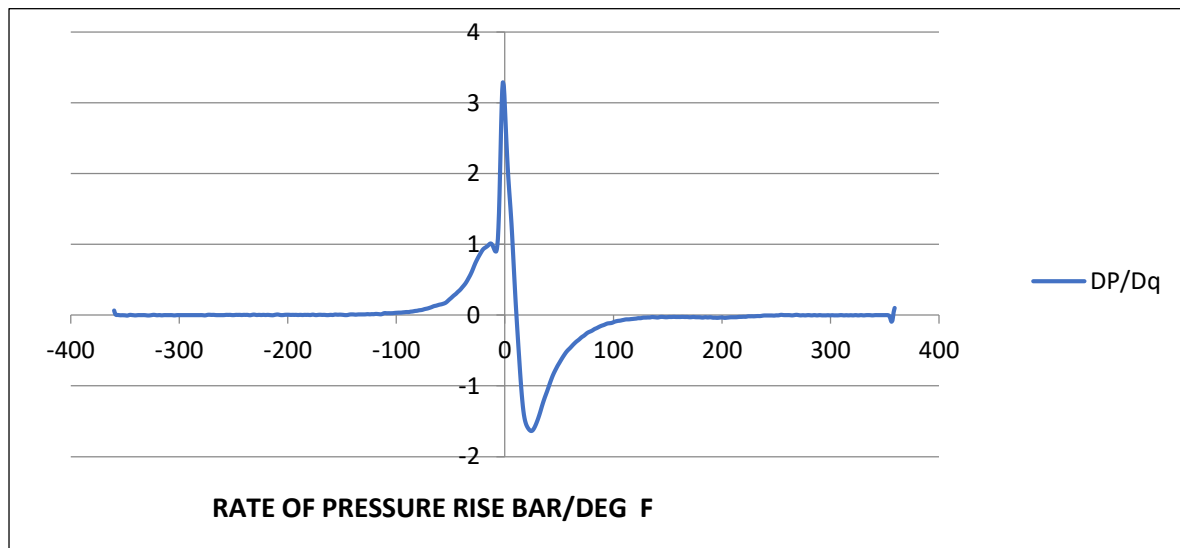


Fig: 5.5: Rate of Pressure Rise Bar/Deg F

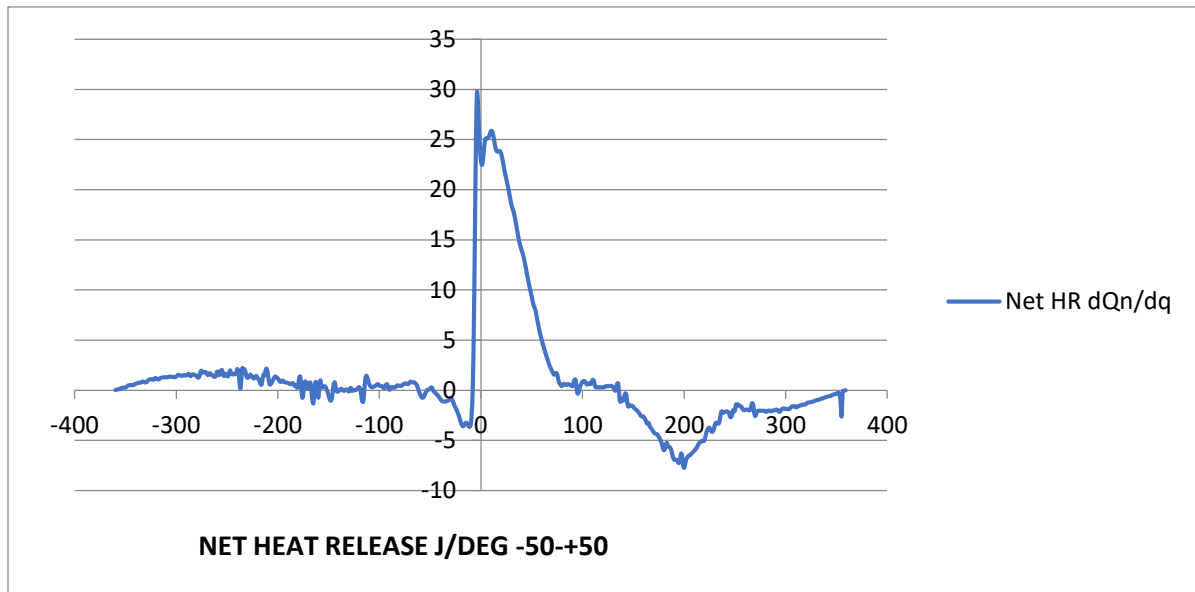


Fig: 5.6: Net Heat Release of Pressure Rise Bar/Deg. F

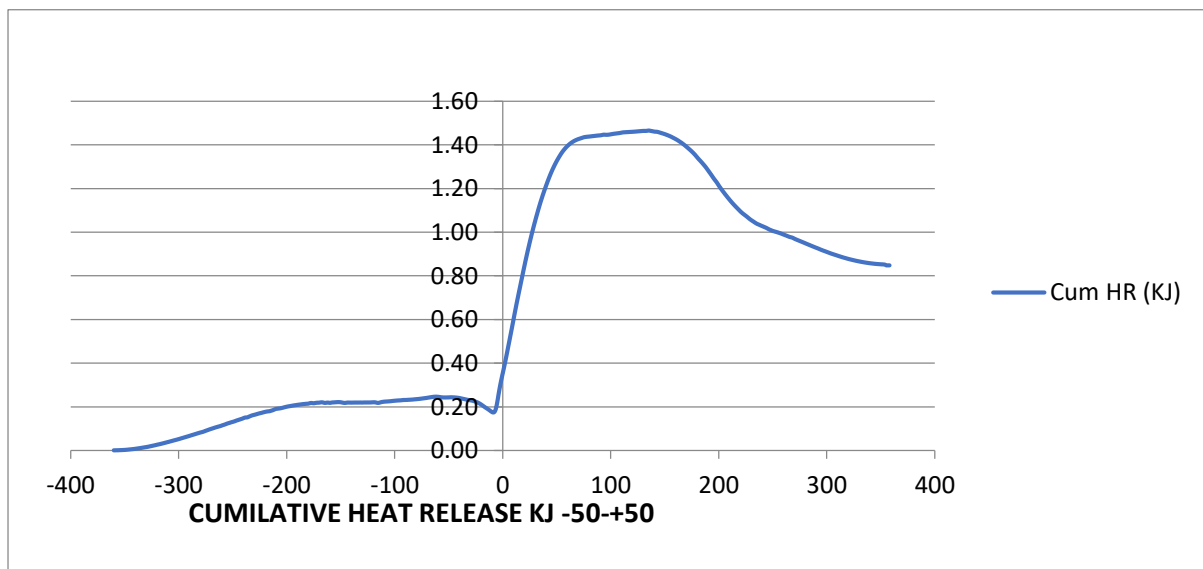


Fig: 5.7: Cumulative Heat Release KJ

25% PROSOPIS JULIFLORA SEED OIL

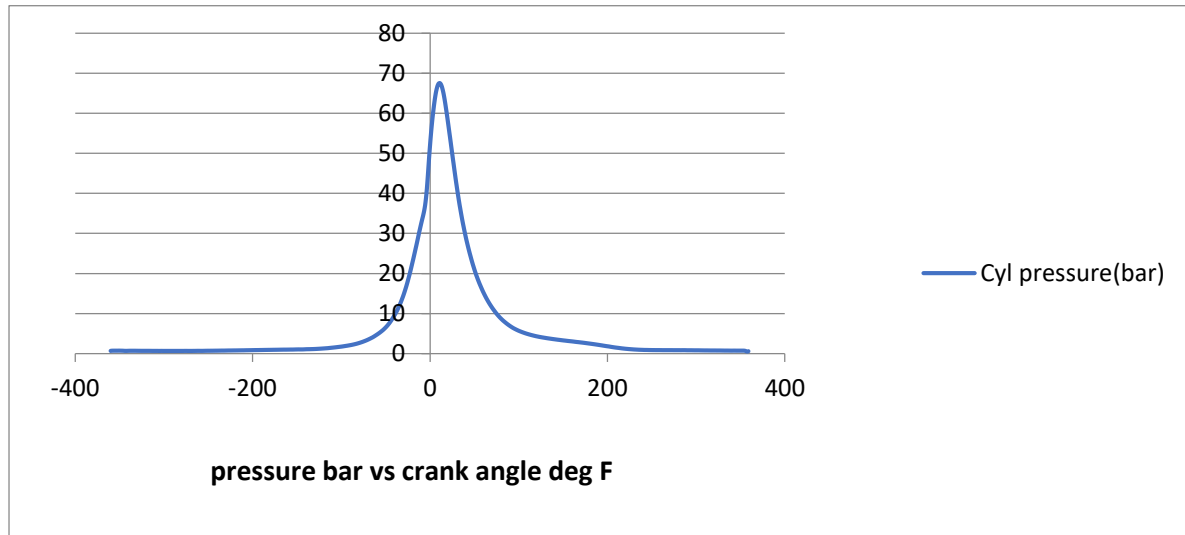


Fig: 5.8: Pressure bar Vs Crank angle deg F

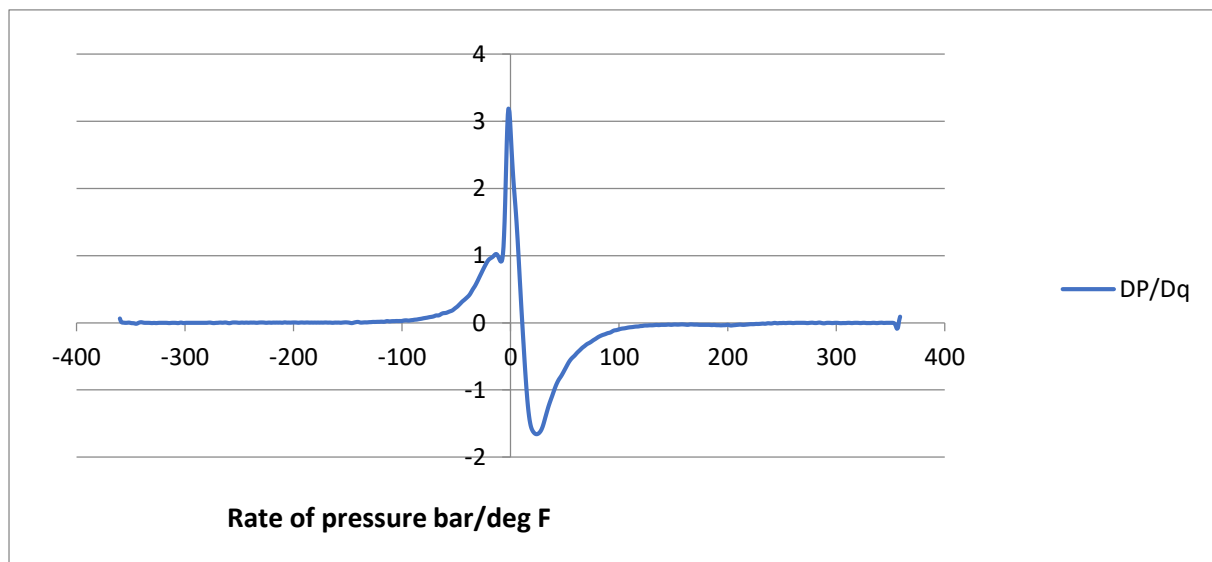


Fig: 5.9: Rate of Pressure Bar/Deg F

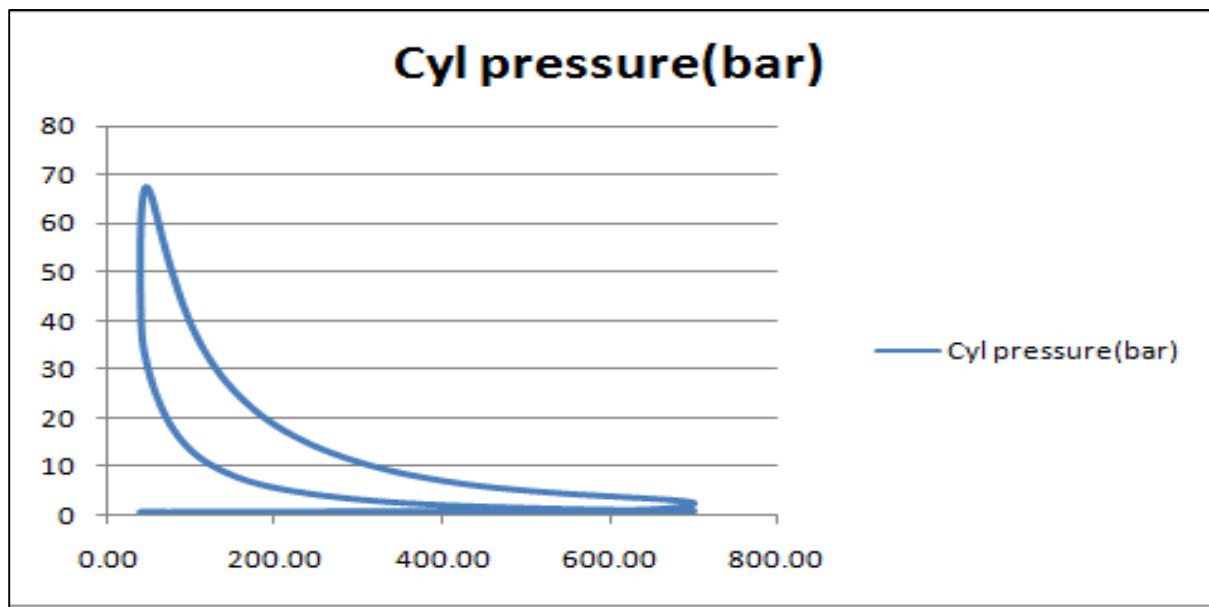


Fig: 5.10: Cylinder Pressure Bar

5.5 PERFORMANCE RESULTS

Table: 5.2: Performance Results

	BP (KW)	Int.Ther Eff.(%)	B.T.Eff. %	SFC (Kg/Kwh)	Mech. Eff.%
Conventional Lubricant	4.98	50.63	33.86	0.25	66.89
10% Bio Lubricant	4.97	48.5	32.46	0.27	66.92
15% Bio Lubricant	4.92	47.68	32.13	0.26	67.39
25% Bio Lubricant	4.93	46.8	31.15	0.28	66.57

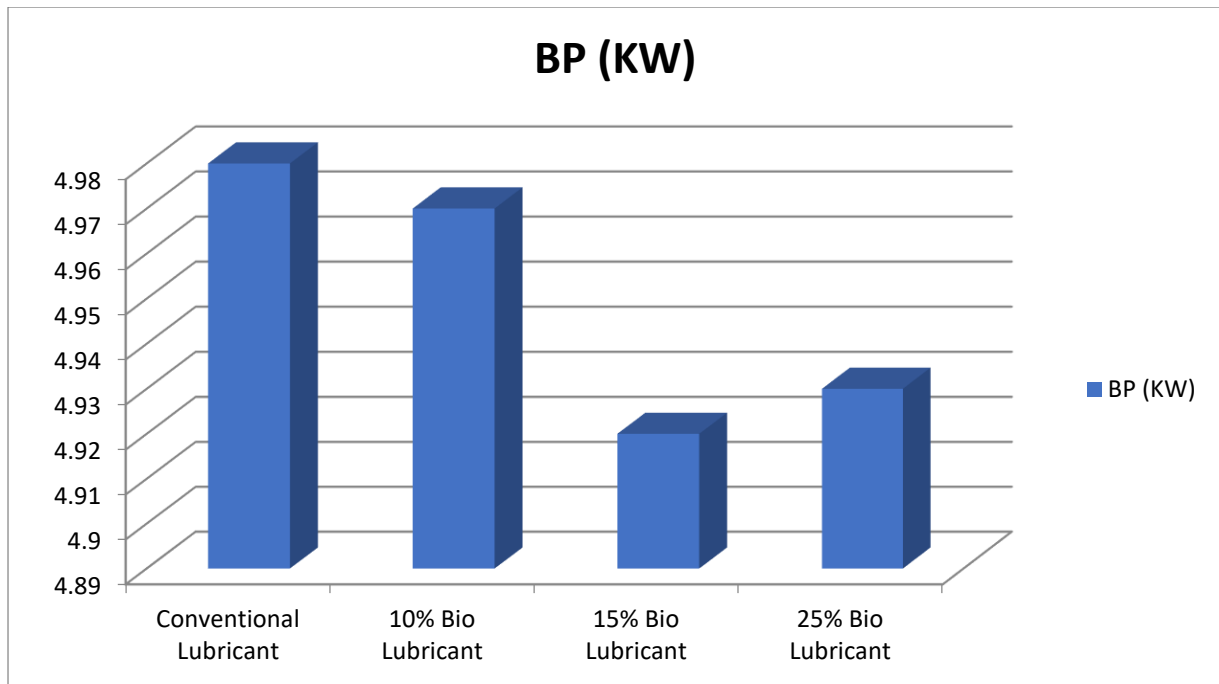


Fig: 5.11: Break Power

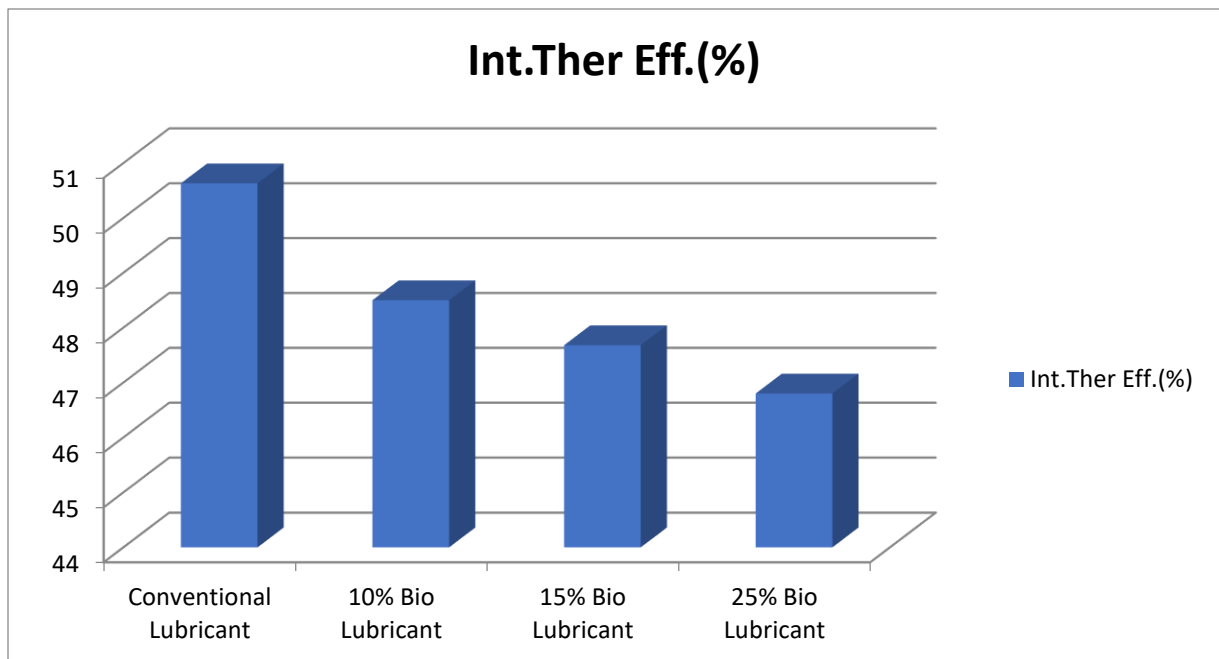


Fig: 5.12: Rate of Pressure Bar/Deg F

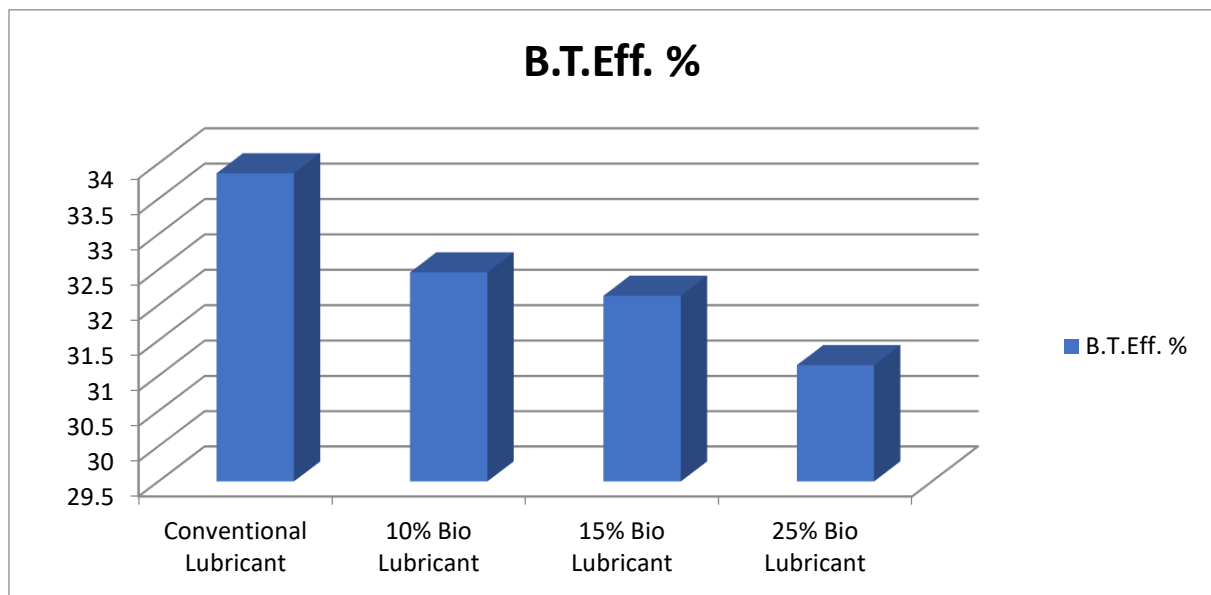


Fig: 5.13: Break Thermal Efficiency %

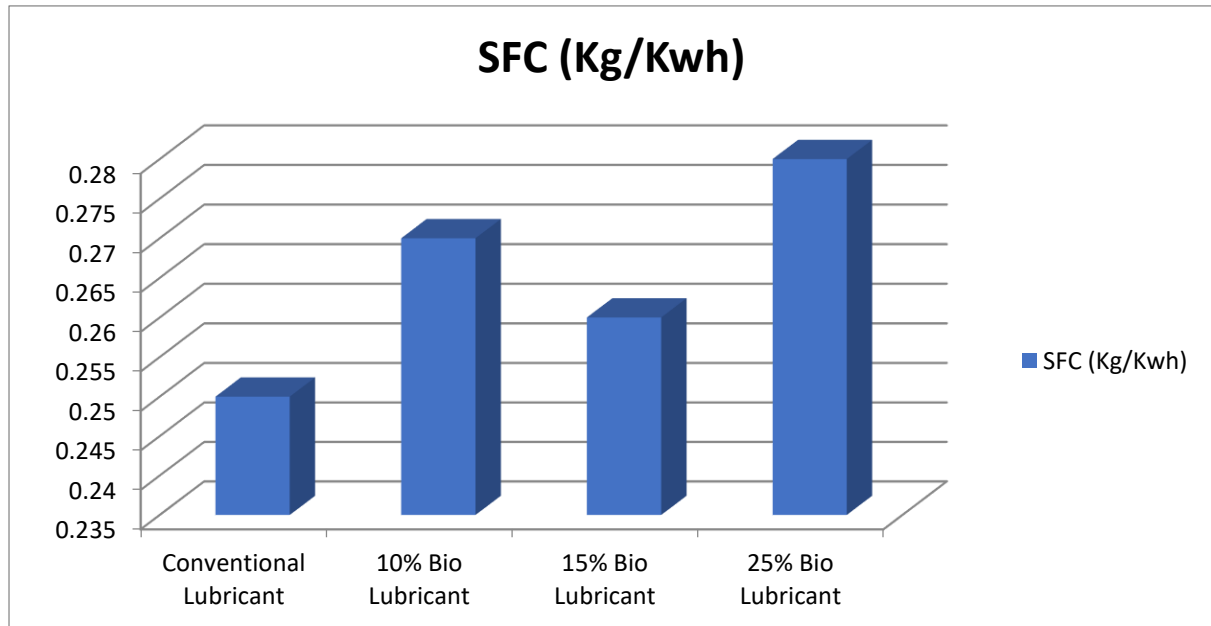


Fig: 5.14: Specific Fuel Consumption

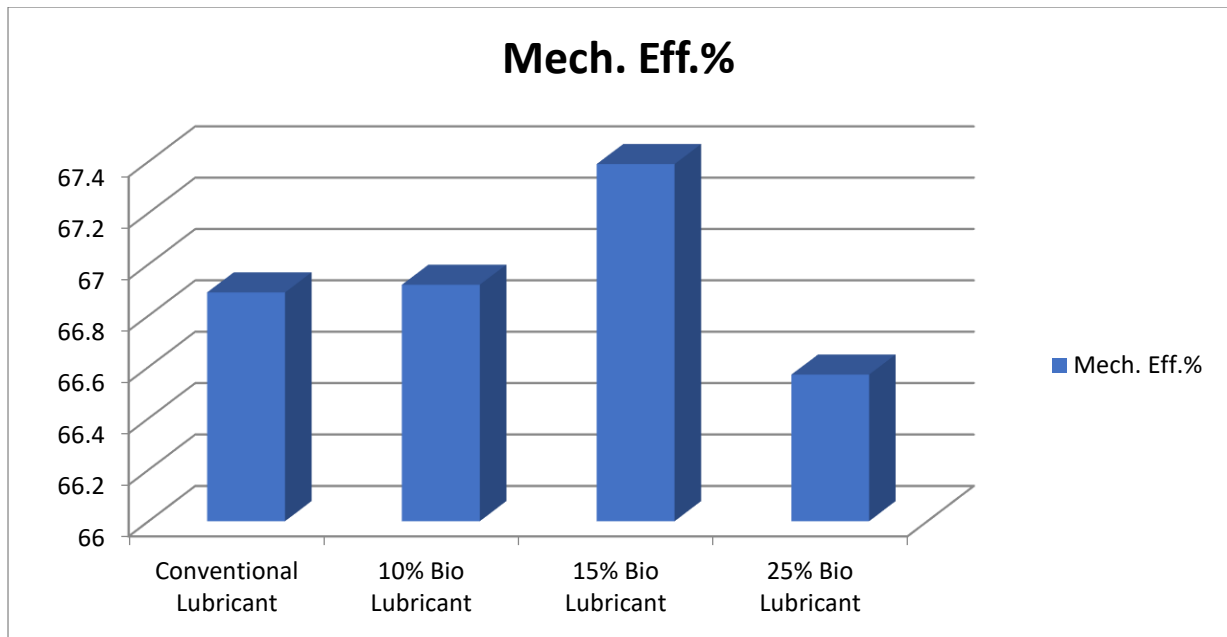


Fig: 5.15: Mechanical Efficiency %

5.6 EMISSION RESULTS

Table: 5.3: Comparison

CO %			
25% OF BIO LUBRICANT	15% OF BIO LUBRICANT	10% OF BIO LUBRICANT	CONVENTIONAL LUBRICANT
0.63	0.53	0.67	0.312

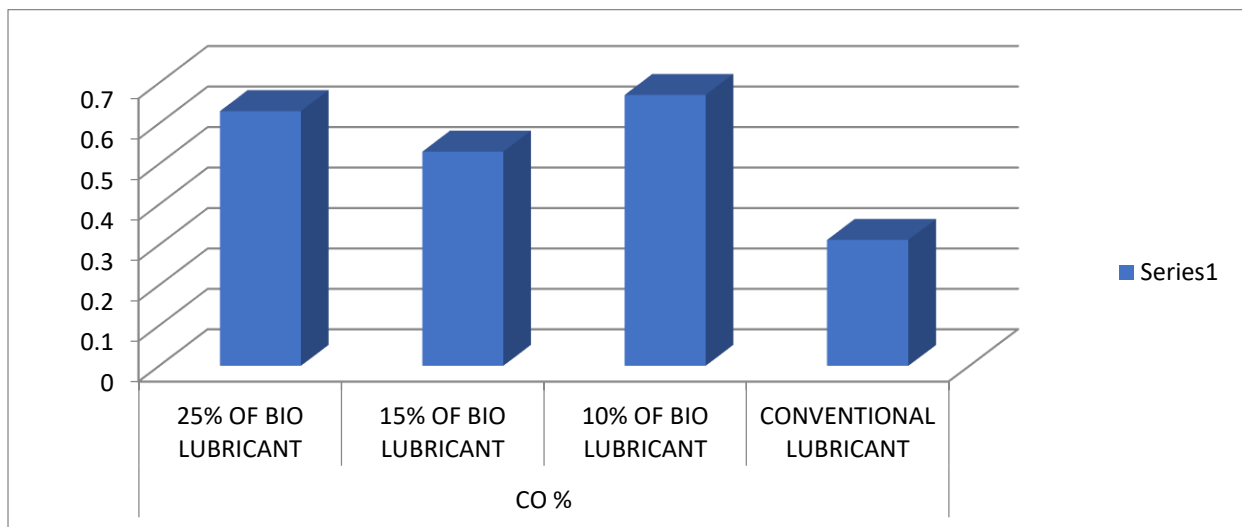


Fig: 5.16: Carbon monoxide emission %

Table: 5.4: Hydrocarbon PPM

HC PPM			
25% OF BIO LUBRICANT	15% OF BIO LUBRICANT	10% OF BIO LUBRICANT	CONVENTIONAL LUBRICANT
81	65	69	49

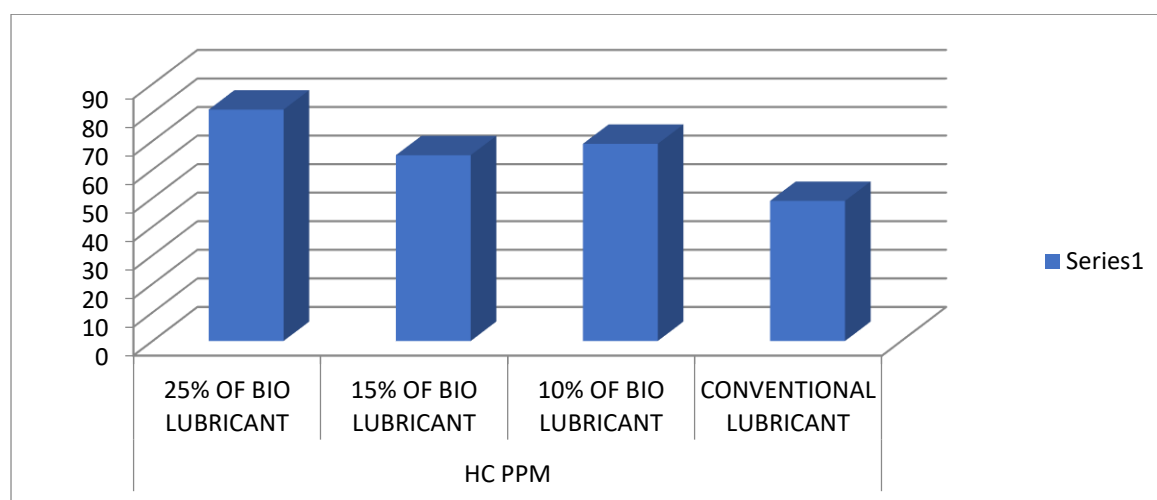


Fig: 5.17: Hydrocarbon PPM

Table: 5.5: CO2 % comparison

CO2 %			
25% OF BIO LUBRICANT	15% OF BIO LUBRICANT	10% OF BIO LUBRICANT	CONVENTIONAL LUBRICANT
10.5	10.4	10.5	10.2

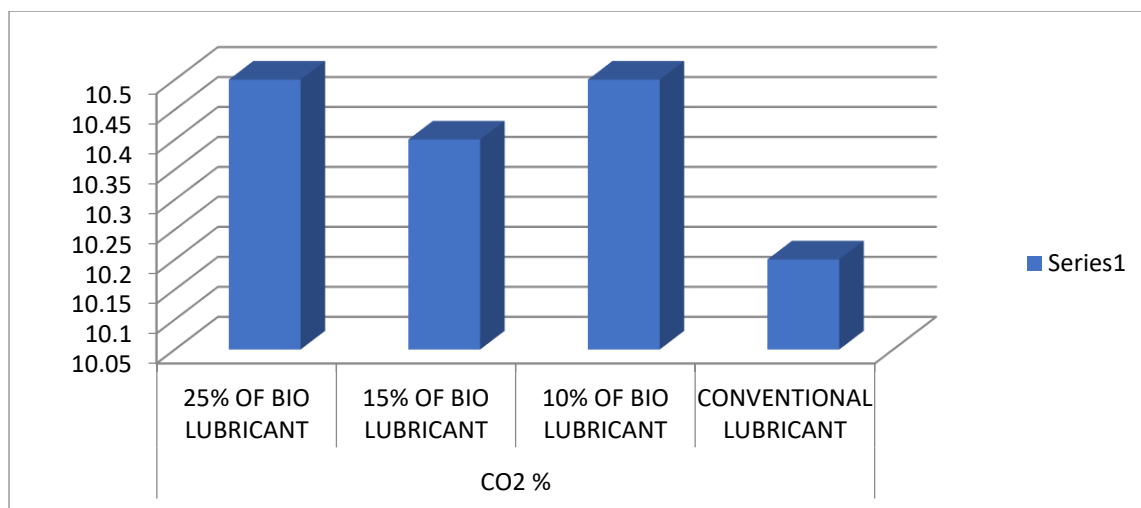


Fig: 5.18: CO2 % comparison

Table: 5.6: Oxygen % Comparison

O2 %			
25% OF BIO LUBRICANT	15% OF BIO LUBRICANT	10% OF BIO LUBRICANT	CONVENTIONAL LUBRICANT
5	5.4	5.17	5.42

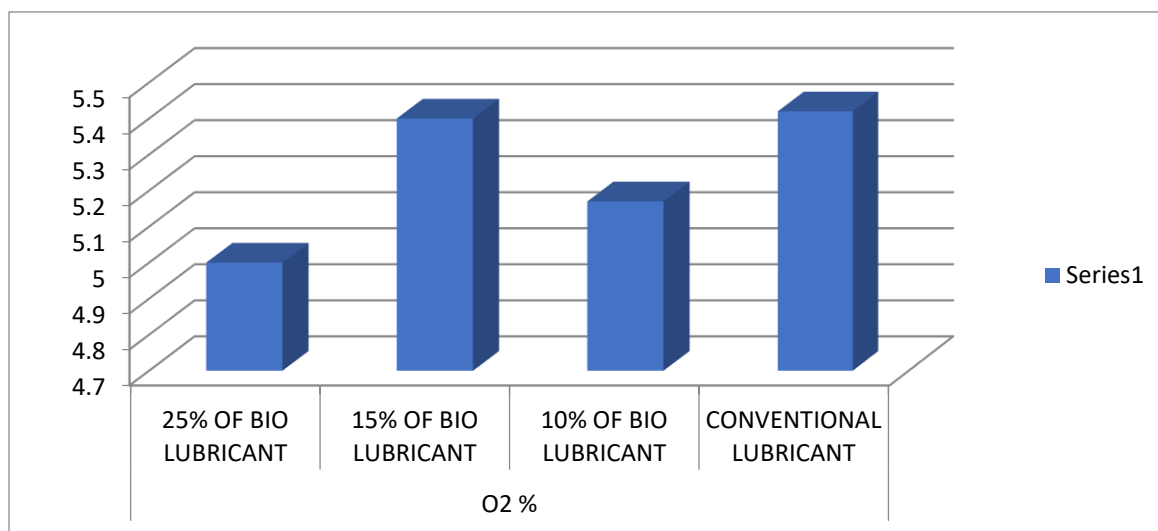


Fig: 5.19: O2 % comparison

Table: 5.7: NOX PPM Comparison

NOX			
25% OF BIO LUBRICANT	15% OF BIO LUBRICANT	10% OF BIO LUBRICANT	CONVENTIONAL LUBRICANT
1553	1551	1598	1694

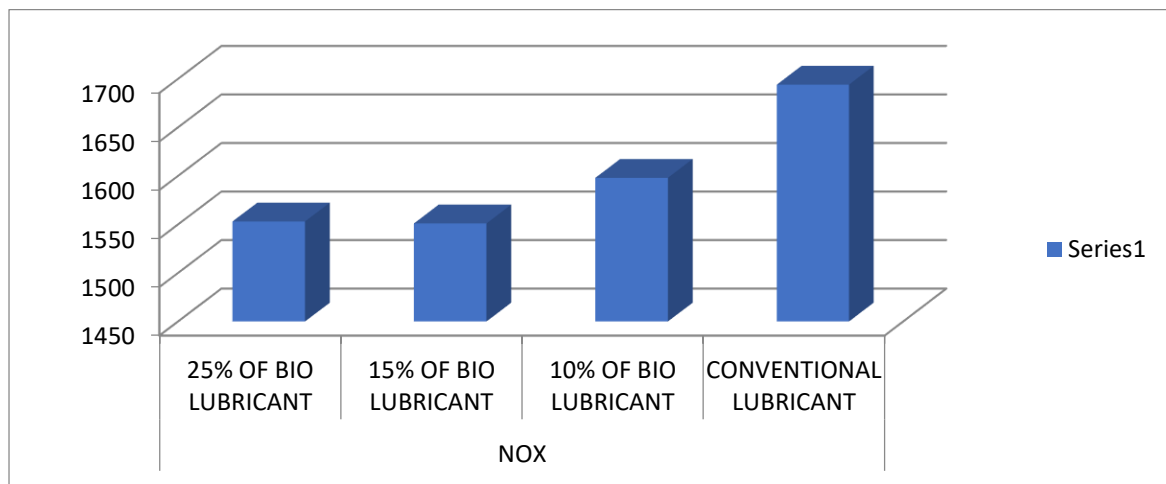


Fig: 5.20: NOX PPM comparison

CONCLUSION

From the obtained experimental investigation, the following conclusions were made

- By means of Bio oil from the prosopis seed, when it was blended with SAE20W40 oil, then the oil properties were increased.
- The chemical properties were increased with the prosopisjuliflora seed oil.
- From the obtained test results, the most suitable proportion for the bio lubricant is 90%SAE-10%prosopis seed oil.
- 85%-15% was provided low flash and fire point, which was suitable for the application of bio lubricant.
- Also, the 85%-15% proportion was provided higher level of viscosity when compared with SAE20W40 oil.

When compared to other bio lubricants, the 15% of bio lubricants was provided better mechanical efficiency and as well as reduce the emission level.

REFERENCES

- [1] Agarwal AK and Das LM (2001) Bio diesel development and characterization for use as fuel in compression engines. Trans. ASME.123, 440- 447.
- [2] A.S. Ramadhas, C. Muraleedharan, S. Jayaraj (2005) Performance and emission evaluation of a diesel Engine fueled with methyl esters of rubber seed oil, Renewable Energy 30 (2005) 1789–1800.
- [3] Ch .S. Naga Prasad , K. Vijaya Kumar Reddy, B.S.P. Kumar, E. Ramjee, O.D. Hebbel and M.C. Nivendgi(2009) Performance and emission characteristics of a diesel engine with castor oil, Indian Journal of Science and Technology ISSN: 0974- 6846 Vol.2 No.10 (2009).
- [4] D. Vashist , and M. Ahmad (2012) Comparative Study of Performance and Emission Characteristics of a Diesel Engine Fueled by Castor and Jatropha Methyl Ester with the Help of T Test, International Journal of Automotive Engineering Vol. 2, No 2, April 2012
- [5] Deshpande D.P., Urunkar Y.D. and Thakare P.D. (2012) Production of Biodiesel from Castor Oil using acid and Base catalysts, Research Journal of Chemical Sciences ISSN 2231-606X Vol. 2(8), 51-56, August (2012).
- [6] DevendraVashist And DrMukhtar Ahmad (2011) A Comparative Study Of Castor And Jatropha Oil Source And Its Methyl Ester Test On The Diesel Engine, International Journal of Engineering Science and Technology, ISSN : 0975-5462 Vol. 3 No. 6 June 2011
- [7] KaziMostafijurRahman, Mohammad Mashud, Md. Roknuzzaman and AsadullahAlGalib, biodiesel from jatropha oil as an alternative fuel for diesel engine. International Journal of Mechanical & Mechatronics IJMME-IJENS Vol: 10 No: 03.

- [8] L. Ranganathan G. Lakshmi NarayanaRao S. Sampath(2011) Experimental Investigation of a Diesel Engine Fuelled With Optimum Biodiesel Produced From Cotton Seed Oil. European Journal of Scientific Research ISSN 1450-216X Vol.62 No.1 (2011), pp. 101-115
- [9] M. C. Navindgi, MaheswarDutta and B. SudheerPrem Kumar (2012) performance evaluation, emission characteristics and economic analysis of four non-edible straight vegetable oils on a single cylinder ci engine, ARPN Journal of Engineering and Applied Sciences ISSN 1819-6608 Vol. 7, No. 2, February 2012.
- [10] M.Prabhahar, R.MuraliManoharandS.Sendilvelan (2012) performance and emission studies of a diesel engine with pongamia methyl ester at different load conditions.International Journal of Engineering Research and Applications ISSN: 2248-9622 Vol. 2, Issue 3 (2012) pp.2707-2713.
- [11] Sejal Narendra Patel, RavindraKirar (2012) An Experimental Analysis of Diesel Engine Using Biofuel at Varying Compression Ratio.International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 10, October 2012.