Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 16, Issue. 1: 2025
ISSN : **1906-9685**

PERFORMANCE AND CHARACTERISTICS OF BIO DIESEL EXTRACTED FROM WASTE PLASTIC

A. Guru Pradeep[1] , Dr.S. Rajendra Prasad[2], S.Pradeep Kumar[3] , P. Sai Kumar[4] , G.Thanush Babu [5] , T. Srinivas[6]

[1]Assistant Professor, Dept. of Mechanical Engineering, Audisankara College of Engineering and Technology
[2]Associate Professor, Dept. of Mechanical Engineering, Audisankara College of Engineering and Technology
[3,4,5,6] B. Tech Student, Dept. of Mechanical Engineering, Audisankara College of Engineering and Technology

ABSTRACT

Now a days the extraction of bio-diesel from waste plastic is an innovative approach to addressing both plastic waste management and the demand for alternative fuels. This process primarily involves pyrolysis, a thermal decomposition method carried out in the absence of oxygen. Waste plastic is heated to high temperatures (typically between 300°C and 600°C), breaking down long polymer chains into smaller hydrocarbon molecules. The resultant product consists of gases, liquid fuel, and char. The liquid fuel fraction, often referred to as plastic-derived oil, can be further refined through catalytic cracking and distillation to produce a bio diesel-like fuel with properties similar to conventional diesel. The final product can be blended with conventional diesel or used directly in modified diesel engines. This method not only reduces environmental pollution caused by plastic waste but also contributes to energy sustainability by providing an alternative fuel source. However, challenges such as feed-stock variability,

The aim of the paper performance of bio-diesel extracted from waste plastic depends on factors such as the type of plastic used, the pyrolysis process, and the degree of refinement. Plastic-derived bio-diesel has a calorific value ranging from 40 to 46 MJ/kg, which is comparable to conventional diesel, ensuring efficient energy output. Its cetane number falls between 45 and 60, indicating good ignition properties, while its viscosity remains within the acceptable range for diesel engines, allowing smooth fuel injection.

Engine performance tests show that plastic-derived bio-diesel produces slightly lower brake thermal efficiency (BTE) compared to conventional diesel due to the presence of residual heavy hydrocarbons, though this can be improved with refining. In terms of emissions, this fuel generates lower CO_2 and CO emissions than conventional diesel, contributing to a reduction in greenhouse gases. However, NO_x emissions are slightly lower due to the high combustion temperatures, similar to trends observed in other biodiesel variants. Additionally, the sulfur content in plastic-derived diesel is negligible, making it an environmentally friendly alternative.

Keywords: pyrolysis, Waste plastics, Bio Fuel and transesterification.

1 INTRODUCTION

Bio-diesel production involves a chemical process called transesterification, where bio diesel or animal fat is reacted with an alcohol (typically methanol) in the presence of a catalyst (like sodium hydroxide) to produce bio-diesel (fatty acid methyl esters) and glycerol as a byproduct; this process is usually depicted in a block diagram with steps including feed-stock preparation, transesterification reaction, separation of bio-diesel and glycerol, and purification of the final bio-diesel product.

Bio-diesel is a renewable, biodegradable fuel derived from natural sources such as vegetable oils, animal fats, and used cooking oil. It serves as an alternative to traditional petroleum-based diesel and can be used in diesel engines with little or no modification.

Biodiesel is produced through a chemical process called **transesterification**, where oils or fats react with an alcohol (usually methanol or ethanol) in the presence of a catalyst (such as sodium hydroxide or potassium hydroxide). This process separates glycerin from the oil, producing **methyl esters (biodiesel)**and glycerol as a byproduct.

1.1 Plastic Waste

Plastic waste refers to discarded plastic objects that haven't been properly recycled or disposed of, a major environmental issue impacting both land and water ecosystems, and raising concerns about human health. It's a global problem, with plastic pollution accumulating in various ecosystems and breaking down into microplastics that enter food chains.

1.1.1 The Problem with Plastic Waste

Environmental Impact:

Plastic pollution can contaminate soil, water, and air, harming ecosystems, and impacting wildlife and human health.

Micro plastics:

When larger plastic waste breaks down, it forms microplastics, which can enter the food chain and accumulate in the bodies of marine organisms, including those consumed by humans.

Economic Impact:

Plastic waste management can impose financial burdens on communities, including the costs of waste collection, disposal, and pollution cleanup.

Waste Management Challenges:

Inadequate waste management systems in many regions contribute to the problem of plastic pollution, as plastic waste may end up in landfills or being dumped into the environment rather than being recycled or treated properly.

1.2 PROPERTIES OF OILS

The properties of oils can be classified as

Physical properties and

Thermal properties

1.2.1 Physical Properties

Few of the physical properties that have been found to be same among all the bio diesel and fuels are:

Mass Density

Kinematic Viscosity

Volatility

Lubricity

Mass Density:

Density or mass density is defined as the ratio of mass of the fluid to its volume. We can also define density as mass of unit volume of a substance. It is denoted the symbol ρ (rho). For Bio Diesel, the density is higher than that of diesel. When put in comparison, the density of Bio Diesel bio diesel is about 10% higher than the density of diesel.

Kinematic Viscosity:

Kinematic viscosity is the resistance to flow of a fluid under gravity, and is measured using a Red wood viscometer. A Red Wood Viscometer is used for these calculations and measurements, and the kinematic viscosity was calculated as the product of the efflux time and the viscometer constant. In general, the kinematic viscosity [m2/s] is the ratio between the dynamic viscosity and the density of a fluid.

Lubricity:

Lubricity measures the load carrying ability or lubricating property of a fluid. Lubricity can also be defined as the measure of the reduction in friction and or wear by a lubricant. A low lubricity fuel may result in high engine wear and a shorter life where as a high lubricity will cause reduced wear and longer life of the engine. Lubricity is measured as the average wear scar diameter in micro meters(μm).

Volatility:

Volatility is one of the vital qualities of bio diesel. It is characterized as the inclination of the oil changes from the fluid into the vapor state at any given temperature. Bio diesel has low volatility, with the goal that bio diesel give great economy and restrict vapor lock. Volatility is specifically identified with a substance's vapor weight.

At a given temperature, a substance with higher vapor weight vaporizes more promptly than a substance with a lower vapor weight.

1.2.2 Thermal Properties

Some of the thermal properties that have been found to be common among the bio diesel are:

Cetane Number

Self-Ignition Response

Pour point

Cloud Point

Flashpoint

Fire Point

Vapor Lock Tendency

Heat of Combustion

Cetane Number:

A relative measure of the interval between the beginning of injection and auto ignition of the fuel. The higher the cetane number, the shorter the delay interval and the greater its combustibility.

The Self-Ignition Response:

It is expressed by the high Cetane Number of diesel fuel. The value should not be lower than 45. The Cetane Number of bio diesel is less than that of diesel. The Cetane Number of monoesters on an average is greater than that of bio diesel.

Pour Point:

Melt or pour point refers to the temperature at which the oil in solid form starts to melt or pour. In cases where the temperatures fall below the melt point, the entire fuel system including all fuel lines and fuel tank will need to be heated.

CloudPoint:

Cloud point is the temperature at which oil starts to solidify. Heating will be necessary in order to avoid waxing of the fuel when an engine is being operated at temperatures below oil's cloud point.

Flash Point:

The flash point temperature of fuel is the minimum temperature at which the fuel will ignite (flash) on application of an ignition source. Flash point varies inversely with the fuel's volatility. Minimum flash point temperatures are required for proper safety and handling of fuel.

Fire Point:

Fire point is the minimum temperature at which the fuel catches fire and burns continuously on the application of test flame. The fire point of oil is more than the diesel.

Vapour Lock Tendency:

If the oil is too volatile, the engine heat will cause it to vaporize in the fuel pump to prevent vapour lock; the fuel oil must have the low volatility. This can cause vapour lock which prevents normal fuel delivery from the fuel injection pump. Thus, the percentage of highly volatile fuel oil must be kept low to prevent vapour lock.

Heat of Combustion:

Heating Value or Heat of Combustion is the amount of heating energy released by the combustion of a unit value of fuels. One of the most important determinants of heating value is moisture content. Air dried biomass typically has about 15-20% moisture, whereas the moisture content for oven-dried biomass is negligible.

1.3 Investigation on Alternative Fuels

After continuous design and development of CI engines, improvements were carried out in order to achieve a good performance and lower emission by varying injection pressure, injection timing, preheating, air flow, combustion chamber geometry and exhaust gas recirculation. Research works carried out on the diesel fuel properties, spray characteristics, mixture formation and combustion process which are key factors. In later development, with the introduction of alternative fuels, the diesel engines were investigated with different fuels; biodiesel and alcohols, investigation were carried out with gaseous fuels such as Hydrogen, Acetylene, liquefied petroleum gas (LPG), compressed natural gas (CNG), Biogas and producer gas with diesel fuel on dual fuel mode

1.4 Introduction of VCR Engine:

The Variable Compression Ratio (VCR) engine is an advanced internal combustion engine technology that allows for adjustments in the compression ratio to optimize performance, efficiency, and emissions. When used with biodiesel, a renewable and eco-friendly alternative to conventional diesel, a VCR engine enhances combustion efficiency by adapting to the fuel's properties, such as its higher viscosity and lower volatility. By varying the compression ratio, the engine can improve power output, reduce fuel consumption, and minimize harmful emissions like nitrogen oxides (NOx) and particulate matter. This adaptability makes VCR engines particularly suitable for biodiesel applications, ensuring a balance between sustainability and engine performance while contributing to greener transportation and energy solutions. The Variable Compression Ratio (VCR) engine is an innovative technology designed to adjust the compression ratio dynamically based on engine load and fuel characteristics. Unlike conventional engines with a fixed compression ratio, VCR engines can optimize performance by modifying the combustion process in real time

2. Literature Review

H.J. Jeong, W.T. Hwang, E.H. Kim, and M.H. Han[1] In this study, Mingshan county—a typical hilly region located on the western edge of the Sichuan basin was selected as the research area. Based on the health risk assessment of Cr(VI), nitrate, fluoride and iron in 41 rural drinking water resources, applying the model recommended by the U.S. Environmental Protection Agency (U.S.EPA), the evaluation grades of health risk associated with drinking water quality (HRWQ) was developed, and the Connection Degree (CD) and the weight of each index of the samples were calculated. And by evaluating them with the criterion of confidence level, Set Pair Analysis (SPA) was established. In this study, it could be seen that the HRWQ of most the resources in the area were of low-medium risk within grade I–III while the HRWQ of some other resources were in a less safe state of medium-high risk.

Smanth R Gouda, Udayakumar J,MahantheshSBPatil[2], Biodiesel has become more attractive recently because of its environmental benefits and the facts that it is made from renewable resources. These concerns have increased the interest in developing second generation biofuels produced from non-food feedstocks such as no edible oils which potentially offer greatest opportunities in the longer term.This paper presents a brief review on the current status of biodiesel production and its performance and emission characteristics as compression ignition engine fuel. This study is based on the reports on biodiesel fuel published in the current literature by different researchers. Biodiesel can be produced from crude vegetable oil, non-edible oil, waste frying oil, animal tallow and also from algae by a chemical process called transesterification. Biodiesel is also called methyl or ethyl ester of the corresponding feed stocks from which it has been produced. Biodiesel is completely miscible with diesel oil, thus allowing the use of blends of petro-diesel and biodiesel in any percentage. Presently, biodiesel is blended with mineral diesel and used as fuel. Biodiesel fueled CI engines perform more or less in the same way as that fueled with the mineral fuel. Exhaust emissions are significantly improved due the use of biodiesel or blends of biodiesel and mineral diesel.

K. Sunil Kumar,AbdulRazak,M. K. Ramis[3] This experimental study based on DOE (Design of experiments) explores the performance and emission characteristics of Moringa oleifera-based biodiesel blends enhanced with zirconium oxide (ZrO_2) and 1-hexanol as boosting agents in a slow-speed diesel engine operating at 1500 rpm. The novelty lies in the synergistic use of these additives for improving fuel efficiency and reducing emissions, combined with advanced statistical and machine learning models for optimization and prediction. Four test blends were analyzed: 90D5MO5H + 25 ppm ZrO_2, 80D10MO10H + 50 ppm ZrO_2, 70D15MO15H + 75 ppm ZrO_2, and 100MO + 100 ppm ZrO_2. A comprehensive methodology involving experimental testing and statistical modelling using Gradient Boosting, Extreme Learning Machine (ELM), and Response Surface Methodology (RSM) was employed. Key findings include a brake thermal efficiency (BTE) of 8.63% higher than diesel and a fuel consumption reduction of 46.13% (0.14 kg/kWh) for the 90D5MO5H + 25 ppm ZrO2 blend. This blend also demonstrated superior combustion characteristics, including a peak cylinder pressure of 70 bar and a heat release rate (HRR) of 45 J/°CA. Emission analysis revealed significantly reduced hydrocarbon emissions (0.020%) for 100MO + 100 ppm ZrO2 and the lowest carbon monoxide emissions (10.1%) for 90D5MO5H + 25 ppm ZrO2. Among predictive models, ELM exhibited the highest accuracy with an R2 value of 0.9604, outperforming other approaches. The findings suggest that optimized moringa oleifera blends with zirconium oxide and 1-hexanol offer a promising solution for sustainable and cleaner diesel engine operation, with potential applications in transportation and energy sectors aiming for reduced environmental impact.

Tikendra Nath Verma,Upendra Rajak[4] The continuous rise in demand, combined with the depletion of the world's fossil fuel reserves, has forced the search for alternative fuels. The biodiesel produced from Roselle is one such indigenous biodiesel with tremendous promise, and its technical ability to operate with compression ignition engines is studied in this work. To characterize the fuel blends, researchers used experimental and empirical approaches while operating at engine loads of 25, 50, 75, and 100%, and with fuel injection timings of 19°, 21°, 23°, 25°, and 27° before top dead center. Results indicate that for 20% blend with the change of injection timing from 19° bTDC to 27° bTDC at full load, brake specific fuel consumption and exhaust gas temperature was increased by 15.84% and 4.60% respectively, while brake thermal efficiency decreases by 4.4%. Also, an 18.89% reduction in smoke, 5.26% increase in CO2, and 12.94% increase in NOx were observed. In addition, an empirical model for full range characterization was created. With an r-squared value of 0.9980 ± 0.0011, the artificial neural network model constructed to characterize all 10 variables was able to predict satisfactorily. Furthermore, substantial correlation among specific variables suggested that empirically reduced models were realistic.

Mohamad Qayyum Mohd Tamam,MdReashedTasvirOmi,WiraJazair Yahya Malaysia[5] is one of the top exporters of palm oil, and although currently facing fierce resistance towards palm oil imports in some parts of the globe, one of the ways to utilize this commodity is by increasing palm biodiesel content in local commercial diesel. However, due to the oxygen-rich nature of biodiesel, its utilization suffers from increased nitrogen oxides (NOx) emission compared to conventional diesel. To mitigate this issue and improve diesel engine performance and emissions using biodiesel–diesel blends, this study attempted to investigate implementation of a real-time non-surfactant emulsion fuel supply system (RTES) which produces water-in-diesel emulsion as fuel without surfactants

Mr. Srinivas KR , Ravi Kumawat[6] N The long-term ambition of energy protection and cooperation, combined with environmental issues of problematic waste accumulation, is tackled through the proposed waste-to- fuel technology. The need to control plastic waste is becoming more evident. This leads to pyrolysis, which is a way to make it very useful to us by recycling them for the production of fuel oil. In this work, plastic waste is used as a source for the production of automotive bio-diesel fuel via a two-step thermochemical process based on pyrolysis and hydro-treatment. As many environmental and social problems arise from plastic waste, re- use technologies are of vital importance in achieving the Sustainable Development Goals (SDG). A potentially cost-effective solution can be accomplished by using waste plastics processed into bio-oil. Thus, the problems faced by the rise in plastic waste and the rising fuel crisis can be avoided by developing a system that can minimize hydrocarbons dependence due to plastics and increase the availability of alternative fuels.

Giridarshan K[7] Plastic waste is generated every day and it is estimated about 15000 tons per day in India.(as per government survey) .The waste plastic which is available in the open gets mixed in a number of ways and goes in with the food of the animals. Thus affecting the humans, animals, earth and environment. Natural Break down and degeneration of plastics takes a very long time in the earth. According to statistics every year about 63% waste plastic is either filled in land or in the natural environment, and some gets mixed and filled in the ocean and water bodies like rivers and lakes.Pyrolysis is a technology used to heating substance in the absence of oxygen that dissolves all these type of waste plastic [1]. The heating temperature should be around 4500C. In this study, paralysis process is used to attain the required temperature, where all the types of waste plastic is being converting to fuel. It works like other fuels like petrol, diesel, and kerosene. By implementing this concept, some amount of waste plastic can be reduced (about 70-80% of waste plastic) and can roughly provide about 50% oil for diesel vehicles. Tests have shown that this fuel does not emit sulfur dioxide and generates about 5% residue as carbon block

Chalita Kaewbuddee[8] This study examined the use of waste plastic oil (WPO) combined with biodiesel as an alternative fuel for diesel engines, also commonly known as compression ignition engines, and focused on comparison of the basic physical and chemical properties of fuels, engine performance, combustion characteristics, and exhaust emissions. A preliminary study was conducted to determine the suitable ratio for the fuel blends in consideration of fuel lubricity and viscosity, and these results indicated that 10% biodiesel—derived from either palm oil or castor oil—in waste plastic oil was optimal. In addition, characterization of the basic properties of these fuel blends revealed that they had higher density and specific gravity and a lower flash point than diesel fuel, while the fuel heating value, viscosity, and cetane index were similar. The fuel blends, comprised of waste plastic oil with either 10% palm oil biodiesel (WPOP10) or 10% castor oil biodiesel (WPOC10), were selected for further investigation in engine tests in which diesel fuel and waste plastic oil were also included as baseline fuels. The experimental results of the performance of the engine showed that the combustion of WPO was similar to diesel fuel for all the tested engine loads and the addition of castor oil as compared to palm oil biodiesel caused a delay in the start of the combustion

3. Methodology

3.1 ENGINE: -

The engine is single cylinder vertical type four stroke, Water-coo1ed, compression ignition engine. The engine is self-governed type whose specifications are given in table 5.1is used in the present work. The above engine is one of the extensively used engines in industrial sector in India. This engine can with stand the peak pressures encountered because of its original high compression ratio. Further, the necessary modifications on the cylinder head and piston crown can be easily carried out in this type of engine. Hence this engine is selected for the present work.

Fig 3.1 Single cylinder four stroke diesel engine test rig

Various Parts of Experimental Setup

Kirloskar diesel engine
Fuel tank
Burette
Valve
Three-way valve
Rope brake dynamometer
Dead mechanical load
Exhaust pipe
Exhaust gas analyzer

3.2 Engine Specifications

The specifications of the Kirloskar engine used in the experimental work are given in the table below.

Table 3.1 Engine specifications

Parameters	**Specifications**
Engine type	Vertical, 4 strokes
Number of cylinders	1
Rated power	3.7 kW/5HP
Bore	80mm
Stroke	110mm
Speed	1500rpm
Compression ratio	16.5:1
Type of cooling	Water cooling

3.3 Bio Diesel Extraction From Waste Plastic:

Biodiesel extracted from waste plastic is a revolutionary approach to tackling both plastic pollution and energy scarcity. With millions of tons of plastic waste generated globally, much of it ends up in landfills or oceans, causing severe environmental damage. Converting this waste into biodiesel through pyrolysis offers a sustainable solution by transforming discarded plastics into a valuable energy source. The process involves heating plastic waste in the absence of oxygen, breaking it down into liquid hydrocarbons, which are then refined to produce biodiesel. This fuel can be used in diesel engines, reducing reliance on fossil fuels and lowering greenhouse gas emissions. Unlike conventional biodiesel made from vegetable oils, plastic-derived biodiesel does not compete with food production, making it an even more sustainable option. Additionally, it offers a practical way to manage non-recyclable plastics that would otherwise persist in the environment for centuries. As technology advances, the production and refinement of biodiesel from waste plastic continue to improve, paving the way for a cleaner and more energy-efficient future.

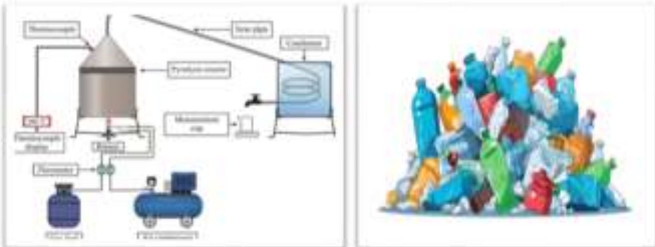


Fig 3.2 Extraction Process and Plastic Waste

The extraction of biodiesel from waste plastic involves a multi-step process that primarily relies on pyrolysis, a thermal decomposition technique carried out in the absence of oxygen. First, collected plastic waste, particularly non-recyclable types such as polyethylene (PE), polypropylene (PP), and polystyrene (PS), is cleaned and shredded into small pieces to enhance the efficiency of the process. These plastic pieces are then fed into a pyrolysis reactor, where they are heated to high temperatures, typically between 300–600°C, without oxygen. Under these conditions, the long-chain polymer molecules break down into smaller hydrocarbon chains, forming a liquid known as pyrolysis oil, along with gaseous byproducts and a small amount of solid residue (char). The pyrolysis oil is then subjected to further refining and distillation to remove impurities and separate fractions with properties similar to diesel fuel. The final product, often referred to as plastic-derived biodiesel, can be blended with conventional diesel or used directly in diesel engines with minimal modifications. This innovative process not only converts plastic waste into a valuable fuel source but also significantly reduces environmental pollution and dependence on fossil fuels, making it a promising solution for sustainable energy production.

Pyrolysis: Plastics Pyrolysis process is used for the purpose. This process uses controlled heating of a material in the absence of oxygen. This is an endothermic process carried out at temperature of 300–600 °C.

3.4 Main Parts In Experimentation Process

3.4.1 Gas Cylinder:

Is Used as a Turbine to Heat the Plastic Waste and It Is Act as A Gas Pressure Tank and Is Help to Extract Bio Gas from Plastic Waste

Fig 3.3 Gas Cylinder After Cutting and Grinding

A gas cylinder is a high-pressure vessel used to store and transport compressed, liquefied, or dissolved gases safely. These cylinders are made from strong materials like steel or aluminum to withstand high pressure and prevent leaks or explosions.

Gas cylinders come in various sizes and are used for different applications, including industrial, medical, and household purposes. Some common types of gases stored in cylinders include oxygen, nitrogen, carbon dioxide, liquefied petroleum gas (LPG), acetylene, and hydrogen. Each type of gas requires specific cylinder designs, pressure ratings, and safety features.

This Gas Cylinder Is Made With Iron Metal It Used In This work To Extract Gas In Pyrolysis Process.The Material Of The Gas Cylinder Is Good To Resist The High Temperature And It Is Used To Heat The Plastic Material

3.4.2 10MM Rods:

A 10 mm rod typically refers to a steel reinforcement bar (rebar) with a diameter of 10 millimeters (mm). These rods are commonly used in construction and civil engineering to provide strength and stability to concrete structures.

Fig 3.4 10MM Rods

10MM RODS Used as locking system of the gas cylinder to stop the gas from inside to outside this is how we are used these rods as shown in the figure

Properties of 10 mm Rods:

Material: Usually made from mild steel, high-yield strength deformed (HYSD) steel, or thermo mechanically treated (TMT) steel.

Strength: TMT bars with a 10 mm diameter have high tensile strength, making them ideal for structural applications.

Weight: A 10 mm steel rod weighs approximately 0.617 kg per meter, depending on the steel grade.

Length: Typically available in standard lengths of 12 meters, but can be cut as required.

Surrface: Can be plain or ribbed (deformed) for better bonding with concrete.

3.4.3 Steel Plate:

The cover plate is used in this work as a cap of the gas cylinder. A steel plate is a flat sheet of steel that comes in various thicknesses, widths, and lengths. It is widely used in construction, manufacturing, shipbuilding, automotive, and industrial applications due to its high strength, durability, and resistance to wear and corrosion.

Fig 3.5 Steel Plate After Welding

3.4.4 Rubber Washer:

A rubber washer in a gas turbine is a small but essential sealing component used to prevent leaks, dampen vibrations, and ensure proper insulation between metal parts. These washers are typically made from high-temperature-resistant elastomers such as silicone, Viton, or nitrile rubber, which can withstand extreme conditions inside a gas turbine.

Fig 3.6 Rubber Washer

3.4.5 Welded Steel Bolt And Steel Nut With 10MM Rod

Fig 3.7 Steel Rod with Bolt

These two are used as the locking system of work and the lock system in a gas turbine is a crucial safety and operational mechanism designed to prevent unintended movement, ensure controlled operation, and protect both the turbine and personnel. It consists of various locking devices that engage during shutdowns, maintenance, or emergency conditions.

3.4.6 Iron Legs:

Fig 3.8 Iron Legs

Iron legs refer to sturdy structural supports made from iron or steel, commonly used in furniture, machinery, and construction. They provide strength, stability, and durability for various applications, ranging from table legs to industrial equipment stands.

3.4.7 Connecting Rod For Gas Passage

Iron gas pipes are widely used for transporting natural gas and propane in residential, commercial, and industrial applications due to their durability and strength. These pipes are typically made from black iron or galvanized iron, with black iron being the preferred choice for gas lines because it lacks the zinc coating that can flake off and cause blockages. Iron gas pipes are known for their ability to withstand high pressure and external damage, making them a reliable option for gas distribution systems. However, they require proper installation and maintenance to prevent leaks and corrosion over time. While newer materials like stainless steel and polyethylene are becoming more common, iron gas pipes remain a trusted choice due to their affordability and long lifespan. Proper sealing with threaded fittings and regular inspections ensure the safety and efficiency of gas supply networks that rely on iron piping.

Fig 3.9 Gas Passage

3.4.8 Final Assembly of Turbine:

This final assembly of gas turbine is completed by different operations like cutting, grinding, drilling and welding.it is finally completed by these operations a gas turbine can play a crucial role in the extraction of biodiesel from waste plastic by providing the necessary thermal energy and power for the pyrolysis process. Pyrolysis is the key method used to break down plastic waste into liquid fuel, which can later be refined into biodiesel

Fig 3.10 Assembly of Extraction Unit

3.4.9 Connecting Passage Tube:

In the biodiesel extraction process, a gas passage tube plays a crucial role in ensuring the efficient removal of unwanted gases and maintaining optimal reaction conditions. This tube is typically used in transesterification reactions, where triglycerides from vegetable oils or animal fats are converted into biodiesel and glycerol in the presence of an alcohol (such as methanol) and a catalyst. The gas passage tube facilitates the escape of byproduct gases, such as methanol vapors and carbon dioxide, which may form during the reaction. By allowing these gases to exit in a controlled manner, the tube helps prevent pressure build-up, reduces unwanted side reactions, and enhances the purity of the final biodiesel product.

Fig 3.11 Gas Passage Tube

3.4.10 Cooling Tub:

Cooling tub is act as condensation system of water cooling.The cooling process in biodiesel extraction is a crucial step that ensures proper phase separation and enhances the quality of the final product. After the transesterification reaction, where triglycerides are converted into biodiesel and glycerol, the reaction mixture is often heated. To facilitate the efficient separation of biodiesel from glycerol and other impurities, the mixture must be gradually cooled.

Fig 3.12 Cooling Tub

Moreover, if excess methanol is used in the reaction, cooling also aids in methanol recovery through condensation. The recovered methanol can then be purified and reused in subsequent reactions, improving process sustainability. Proper cooling not only enhances product yield but also ensures the biodiesel meets quality standards by reducing unwanted impurities and improving its clarity and stability.

3.4.11 Storage Can

In the biodiesel extraction process, the storage can plays a crucial role in maintaining the quality and stability of the produced biodiesel. After the extraction and purification process, biodiesel needs to be stored in a well-sealed, contamination-free environment to prevent degradation.Regular monitoring of stored biodiesel is necessary to ensure it retains its fuel properties and remains suitable for use in engines or blending with conventional diesel. Proper storage not only enhances the shelf life of biodiesel but also ensures its efficient performance when used as an alternative fuel.

Fig 3.15 Storage Can

3.4.12 Final Project Setup:

This is the work final setup to assemble all the parts for the purpose of extraction process of bio diesel from waste plastic.

Fig 3.16 Extraction Process

4 Test Procedure, Formulae and Tabulations:

4.1 Test Procedure:

- The experimental procedure of this investigation is explained further below.
- Before starting of the engine, the different blends of bio diesel are to be kept ready and the fuel tank of the engine should be filled with diesel according to the requirement.
- Engine is started and kept running for some time and then the time taken for consumption of volume of 10cc diesel fuel is noted by seeing the reading in the burette at no load condition.
- Then a load is added to the spring balance and engine is kept idle running for 5 min so that constant rpm of 1500 is attained.
- Then the reading for 10cc fuel consumption is again noted.
- The same is repeated for all the loads and the time values are noted for the same separately.
- Now the valve from the fuel tank to the engine is cut-off and the engine is run till the diesel in the burette gets empty.
- Now blend of any choice is added to the burette and the engine is kept running for some time so that this fuel blend gets completely inside engine.
- Once this is done, the steps 2-6 are repeated with different loads and the time taken readings are noted
- At the same time for every sample and for each load the exhaust emissions are noted from the readings of exhaust analyzer which is connected to the exhaust.
- Now the engine is shut down.
- Once all the readings are noted down calculations are done and graphs are plotted for performance parameters at different loads and compared.

4.2 Formulae:

The parameters that are determined at different loads are as follows:

1.BrakePower, B. P= $\frac{2\pi NT}{60\times 1000}$ kW

Where,

T = Torque, NM

N = Speed,rpm

Brake Power, B. P= kW

Torque applied, T = W xr

Where,

W= load applied, kg r= radius of brake drum, m

2.T.F.C = 10x specific gravityKg/s t x 1000

Where, t = Time taken for 10cc fuel, seconds

T. F.C = Total Fuel Consumption, Kg/s

Specific gravity of diesel = $\frac{\text{density}}{1000}$

3.Brake Specific Fuel Consumption,

= CalorificValueofFuel, kJ/kgk

5.FrictionalPower,

F. P = kW(fromgraphbyWilliam'sline method)

6.IndicatedPower = B.P+F. P

IndicatedPower kW

7.Brake thermal efficiency

$$\eta bth = \frac{B.P}{\text{Heat Input}} \times 100\%$$

8.Indicated thermal efficiency

$$\eta ith = \frac{I.P}{\text{Heat Input}} \times 100\%$$

9.Brake Mean Effective Pressure,

$$bmep = \frac{B.P \times 60}{L \times A \times n \times k} \text{ kN/m2}$$

Where L = length of the stroke, m n = speed of the engine = 1500/2 A = Area of the cylinder, m2 k = no. of cylinders

10.Indicated Mean Effective Pressure,

$$Imep = \frac{I.P \times 60}{L \times A \times n \times k} \text{kN/m2}$$

Where L = length of the stroke, m n = speed of the engine = 1500/2 A = Area of the cylinder, m2 k = no. of cylinders

4.3Tabulations:

4.3.1 Performance Test Calculation for Plastic Oil

Table 4.1 Pure Diesel Performance

Load (amp)	BP (kw)	TFC (Kg/hr)	SFC (Kg/kwhr)	I.P (kw)	ηmech %	ηBT %
0	0	0.478	0	0.8	0	0
2.5	0.718	0.548	0.762	1.518	47.32	10.53
5	1.437	0.625	0.435	2.237	64.25	18.47
7	2.012	0.776	0.385	2.812	71.55	20.83

Brake Power (BP) = VIcos/(AE 1000)

= (230* 2.5 *1)/ (0.8* 1000)

= 0.7187kw

Total Fuel Consumption (TFC) = 3.6x/t specific_gravity

=(3.6* 10/54.5) 0.83

=0.548kg/hr

Specific fuel consumption=TFC/BP

$$Bsfc = \frac{T.F.C}{B.P} \text{ Kg/kwh}$$

4.Heat Input Where, = T.F.C X C.V kW

=0.548/ 0.7187

=0.7623kg/kWhr.

Mechanical efficiency (ηmech) = (BP/IP) 100

= (0.7187/1.518) 100

=47.32%

Brake thermal efficiency (ηbt) =((bp* 3600)/(tfc* 44800)) 100

=(0.718 *3600)/(0.548* 44800) 100

=10.53%.

4.3.2 Performance Test on Mixture of WPO (10%) And diesel (90%):

Table 4.2 Performance on WPO (10%) and Diesel (90%)

Load (amp)	BP (kw)	TFC (kg/hr)	SFC (kg/kw hr)	I.P (kw)	ηmech %	ηBT %
0	0	0.372	0	0.7	0	0
2.5	0.727	0.484	0.665	1.427	50.94	12.19
5	1.455	0.537	0.369	2.155	67.51	21.99
7	2.037	0.668	0.327	2.737	74.45	24.76

Brake Power (BP) =VIcos / (AE *1000)

= (230*2.5*1)/ (0.7*1000)

= 0.821kw

Total Fuel Consumption (TFC) = 3.6x/t*specific gravity

=(3.6*10 /54.5)*0.76

= 0.502 kg/h

Specific fuel consumption (SFC) = TFC / BP

= 0.502 / 0.821

= 0.611 kg/kW-hr

Mechanical efficiency (ηmech) = (BP/IP)*100

= (0.727/1.427)*100

= 50.94%

Brake thermal efficiency (ηbt)

= ((bp*3600)/(tfc*44800))*100

=(0.727*3600)/(0.484*44800)*100

= 12.19%

Table 4.3 Performance on WPO (15%) and Diesel (85%)

Load (amp)	BP (kw)	TFC (kg/hr)	SFC (kg/kw hr)	I.P (kw)	ηmech %	ηBT %
0	0	0.319	0	0.65	0	0
2.5	0.731	0.452	0.616	1.381	52.75	13.02

5	1.464	0.493	0.336	2.114	69.14	23.75
7	2.049	0.611	0.298	2.669	75.9	26.72

Table 4.4 Performance On WPO (20%) and Diesel (80%)

Load (amp)	BP (kw)	TFC (kg/hr)	SFC (kg/kw hr)	I.P (kw)	ηmech %	ηBT %
0	0	0.266	0	0.6	0	0
2.5	0.736	0.420	0.568	1.336	54.56	13.85
5	1.473	0.449	0.303	2.073	70.77	25.51
7	2.062	0.560	0.269	2.662	77.35	28.69

Brake Power (BP) =VIcos / (AE *1000)
= (230*2.5*1)/ (0.6*1000)
= 0.958kw

Total Fuel Consumption (TFC) = 3.6x/t*specific gravity
= (3.6*10 /54.5)*0.69
= 0.455kg/hr

Specific fuel consumption (SFC) = TFC / BP
= 0.455/ 0.958
= 0.474kg/kW-hr

Mechanical efficiency (ηmech) = (BP/IP)*100
= (0.736/1.336)*100
= 55.08%

Brake thermal efficiency (ηbt)
= ((bp*3600)/(tfc*44800))*100
=(0.736*3600)/(0.420*44800)*100
= 14.08%

5.RESULTS AND DISCUSSIONS

Load (amp)	BP (kw)				TFC (kg/hr)				SFC(kg/kwhr)			
	Diesel	WPO 10%	WPO 15%	WPO 20%	Diesel	WPO 10%	WPO 15%	WPO 20%	Diesel	WPO 10%	WPO 15%	WPO 20%
0	0	0	0	0	0.478	0.372	0.32	0.27	0	0	0	0
2.5	0.718	0.727	0.731	0.74	0.548	0.484	0.45	0.42	0.762	0.665	0.62	0.568
5	1.437	1.455	1.464	1.44	0.625	0.537	0.49	0.45	0.435	0.369	0.34	0.303
7	2.012	2.037	2.049	2.06	0.776	0.668	0.61	0.56	0.385	0.327	0.3	0.269

Load (amp)	I.P (kw)				ηmech %				ηBT %			
	Diesel	WPO 10%	WPO 15%	WPO 20%	Diesel	WPO 10%	WPO 15%	WPO 20%	Diesel	WPO 10%	WPO 15%	WPO 20%
0	0.8	0.7	0.65	0.6	0	0	0	0	0	0	0	0
2.5	1.518	1.427	1.38	1.34	47.32	50.94	52.75	54.56	10.53	12.19	13	13.85
5	2.237	2.155	2.11	2.07	64.25	67.51	69.14	70.77	18.47	21.99	23.8	25.51
7	2.812	2.737	2.67	2.66	71.55	74.45	75.9	77.35	20.83	24.76	26.7	28.69

5.1 GRAPHS:

Thesegraphs play a crucial role in analyzing and interpreting mechanical performance. Given graphs are explain about brake power, fuel consumption and mechanical efficiency etc., graphs help engineers and technicians understand engine performance, optimize fuel usage, and improve overall efficiency.

5.1.1 BRAKE POWER COMPARISON FOR DIESEL AND BIOFUEL (10%)

Brake power is increased when load is applied gradually, blended bio diesel (10%) is give better performance compared to pure diesel as shown in graph (5.1.1)

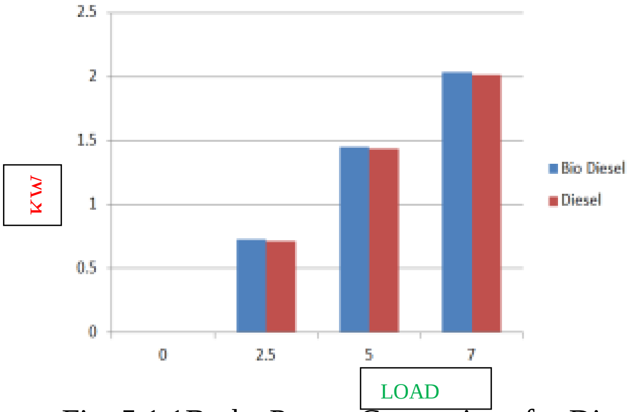


Fig: 5.1.1Brake Power Comparison for Diesel and Bio-fuel (10%)

5.1.2 TOTAL FUEL CONSUMPTION COMPARISON FOR DIESEL AND BIOFUEL (10%)

Total fuel consumption graph explain when the load is applied gradually to blended bio diesel (10%) consumption is decreased compared to pure diesel shown in graph (5.1.2)

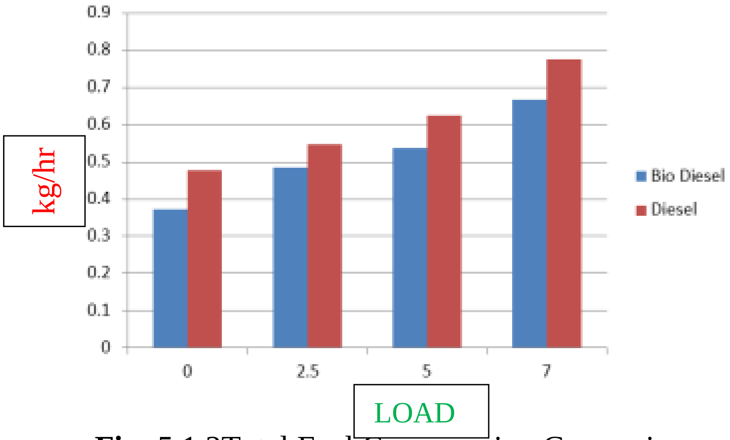


Fig: 5.1.2Total Fuel Consumption Comparison for Diesel and Bio-fuel (10%)

5.1.3 MECHANICAL EFFICIENCY COMPARISON FOR DIESEL AND BIOFUEL (10%)

Mechanical efficiency is increased when load is applied gradually to engine which is blended with bio diesel (10%), so bio-diesel gives more efficiency compared to pure diesel shown in graph (5.1.3).

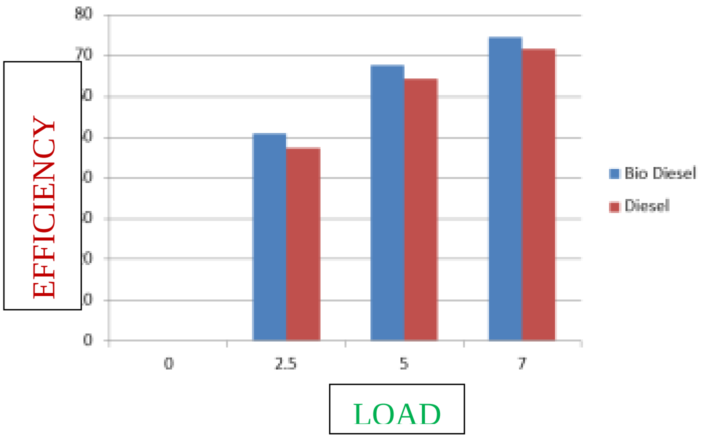


Fig: 5.1.3 Mechanical Efficiency Comparison for Diesel and Bio-fuel (10%)

5.1.4 BRAKE POWER COMPARISON FOR DIESEL AND BIOFUEL (15%)

Brake power is increased when load is applied gradually, blended bio diesel (15%) is give better performance compared to pure diesel as shown in graph (5.1.4)

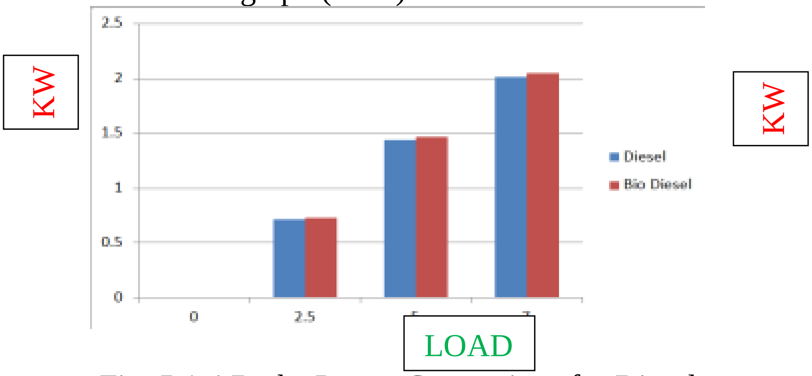
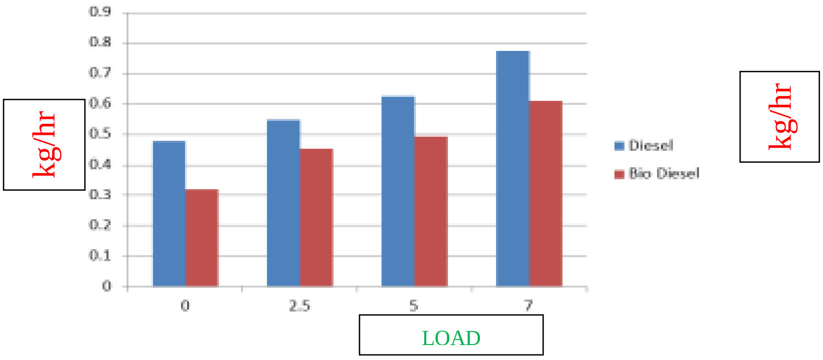


Fig: 5.1.4 Brake Power Comparison for Diesel and Biofuel (15%)

5.1.5 TOTAL FUEL CONSUMPTION FOR DIESEL AND BIOFUEL (15%)

Total fuel consumption graph explain when the load is applied gradually to blended bio diesel (15%) consumption is decreased compared to pure diesel shown in graph (5.1.5)



Graph 5.1.5 Total Fuel Consumption for Diesel and Bio fuel (15%)

5.1.6 MECHANICAL EFFICIENCY FOR DIESEL AND BIOFUEL (15%)

Mechanical efficiency is increased when load is applied gradually to engine which is blended with bio diesel (15%), so bio diesel gives more efficiency compared to pure diesel shown in graph (5.1.6).

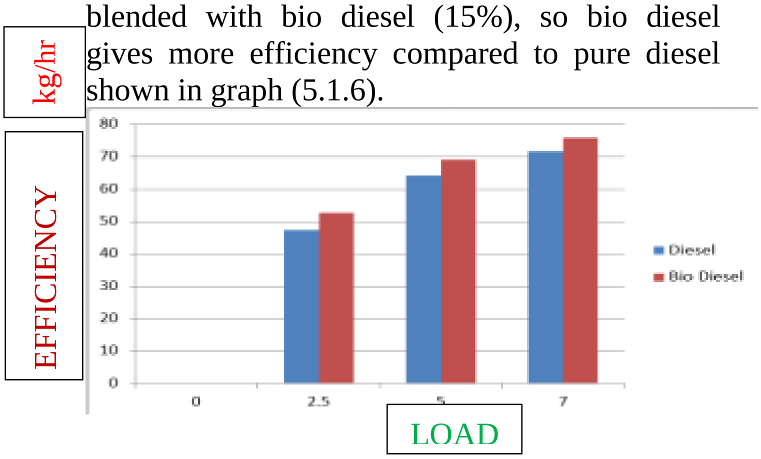


Fig: 5.1.6 Mechanical Efficiency for Diesel and Biofuel (15%)

5.1.7 BRAKE POWER COMPARISION FOR DIESEL AND BIODIESEL (20%)

Brake power is increased when load is applied gradually, blended bio diesel (20%) is give better performance compared to pure diesel as shown in graph (5.1.7)

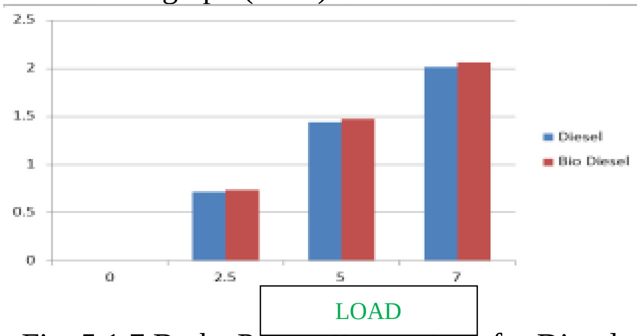


Fig: 5.1.7 Brake Power Comparison for Diesel and Bio-diesel (20%)

5.1.8 TOTAL FUEL CONSUMPTION FOR DIESEL AND BIODIESEL (20%)

Total fuel consumption graph explain when the load is applied gradually to blended bio diesel (20%) consumption is decreased compared to pure diesel shown in graph (5.1.8)

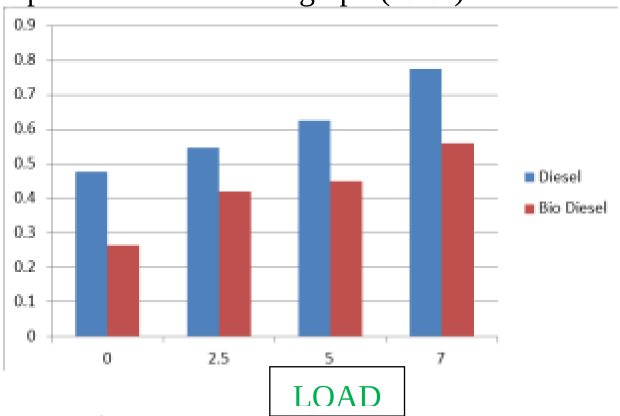


Fig:5.1.8 Total Fuel Consumption for Diesel and Bio diesel (20%)

5.1.9 MECHANICAL EFFICIENCY FOR DIESEL AND BIOFUEL (20%)

Mechanical efficiency is increased when load is applied gradually to engine which is blended with bio diesel (20%), so bio diesel gives more efficiency compared to pure diesel shown in graph (5.1.9).

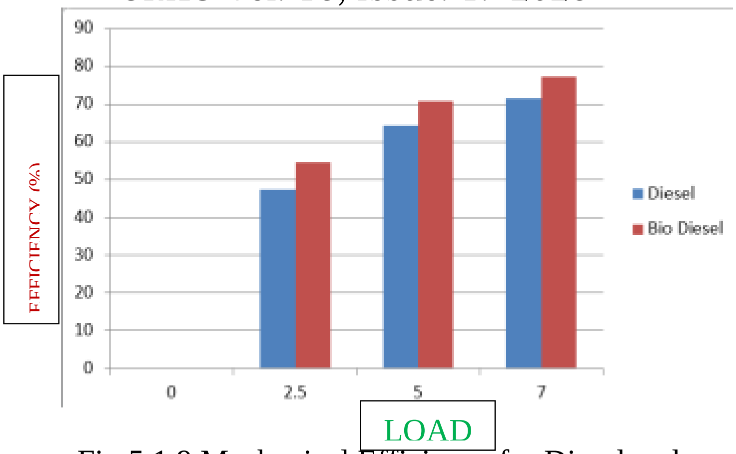


Fig:5.1.9 Mechanical Efficiency for Diesel and Biofuel (20%)

In order to improve the properties of waste plastic oil by combination with biodiesel, such as through increasing the oxygen content in the waste plastic oil for better combustion and to improve the viscosity and lubricity of the waste plastic oil, COME (castor oil methyl ester) and POME (POME is typically high in **biological oxygen demand (BOD) of ~25 000 mg litre-1 and chemical oxygen demand (COD) of ~50 000 mg litre-1)**were blended with waste plastic oil at different volumetric ratios, ranging from 0% to 15%, and the basic physical and chemical properties of the blended fuels were investigated, which mainly focused on fuel lubrication and viscosity. It can be concluded that the presence of 10% biodiesel in waste plastic oil is the optimal ratio because the smallest scar diameter was obtained after lubrication testing and the viscosity was within the acceptable criteria prescribed by the standard specification for diesel fuel, as shown in Figure 3. The lubricity testing was evaluated by a high-frequency reciprocating rig (HFRR) and was conducted according From the preliminary experiment, 10% biodiesel was enough to maintain the lubrication of the blended fuel and there was no significant improvement in the lubrication of the blend when exceeding this percentage of biodiesel in waste plastic oil. Therefore, a combination of either 10% castor oil biodiesel or 10% palm oil biodiesel with 90% waste plastic oil (WPOC10 and WPOP10, respectively) was selected for further investigation in the engine test to study the effect of biodiesel addition to waste plastic oil on engine performance, combustion characteristics, and exhaust emissions.

6. CONCLUSION

Finally by Concluding this paper can use this blended biodiesel as a alternative source of fuel from waste plastic through pyrolysis process. Thus, we have done the process of fabrication for extracting biodiesel by using plastic waste .By using more techniques also possible to develop biodiesel according to the applications.

The solution for environmental and energy issues are fulfilled by pyrolysis, which has been found the most effective technique of conversion of waste plastic to fuels. It has the potential to convert most energy from plastic waste to liquid, gas and char. The use of this oil in diesel engine in the aspect of technical and economical is compared and found that the oil is able to replace the diesel oil. The liquid obtained in this process has relatively higher volume and low boiling range. It is noticeable that the fuel obtained in this process is cleaner compared to the conventional fuels.

This method not only reduces environmental pollution caused by plastic waste but also contributes to energy sustainability by providing an alternative fuel source. However, after performance test different results have been found and plotted the various graphs as a comparative manner like Mechanical efficiency, Brake thermal efficiency, Total fuel consumption etc. In terms of emissions, this fuel generates lower CO_2 and CO emissions than conventional diesel, contributing to a reduction in greenhouse gases. However, NO_x emissions are slightly lower due to the high combustion temperatures, similar to trends observed in other biodiesel variants. Additionally, the sulfur content in plastic-derived diesel is negligible, making it an environmentally friendly alternative.

Different results have been found and plotted the various graphs as a comparative manner like Mechanical efficiency, Brake thermal efficiency, Total fuel consumption etc. In terms of emissions, this fuel generates lower CO_2 and CO emissions than conventional diesel, contributing to a reduction in greenhouse gases. However, NO_x emissions are slightly lower due to the high combustion temperatures, similar to trends observed in other biodiesel variants. Additionally, the sulfur content in plastic-derived diesel is negligible, making it an environmentally friendly alternative.

REFERENCES

1. H.J. Jeong, W.T. Hwang, E.H. Kim, and M.H. Han, “Radiological risk assessment for an urban area: Focusing on a drinking water contamination,” Annal Nuclear Energy, vol. 36 Sep.2009, pp.1313-1318, doi:10.1016/j.anucene.2009.07.008
2. Smanth R Gouda, Udayakumar J,MahantheshSBPatil “A REVIEW PAPER ON BIODIESEL: A PROMISING ALTERNATIVE FUEL", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.6, Issue 3, page no.154-160, March-2019,
3. Kumar, K.S., Razak, A., Ramis, M.K. et al. Statistical and machine learning analysis of diesel engines fueled with Moringa oleifera biodiesel doped with 1-hexanol and Zr2O3 nanoparticles. Sci Rep 15, 7269 (2025). https://doi.org/10.1038/s41598-025-87818-7
4. Upendra Rajak ⇑ ,Tikendra Nath Verma “Influence of combustion and emission characteristics on a compression ignition engine from a different generation of biodiesel” Engineering Science and Technology, an International Journal 23 (2020) 10–20
5. Mohamad Qayyum Mohd Tamam,MdReashedTasvirOmi,WiraJazair Yahya Malaysia “Effects of Ethanol Blending with Methanol-Gasoline fuel on Spark Ignition Engine Performance and Emissions” Journal of Advanced Research in Fluid Mechanics and Thermal SciencesISSN (Online): 2289 – 7879
6. Srinivas K R, Ravi Kumawat N, Pronob Jyoti Gogoi, Rahul Prasad Singh Yadav, 2022, Extraction of Bio-Diesel From Waste Plastic Through Pyrolysis Process, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ACME – 2022 (Volume 10 – Issue 10)
7. Giridarshan K “Bio Diesel Extraction from Waste Plastic Material” Institute of Scholars (InSc), 2020 Kaewbuddee, C.; Sukjit, E.; Srisertpol, J.;
8. Maithomklang, S.; Wathakit, K.; Klinkaew, N.; Liplap, P.; Arjharn, W. Evaluation of Waste Plastic Oil-Biodiesel Blends as Alternative Fuels for Diesel Engines. Energies 2020, 13, 2823. https://doi.org/10.3390/en13112823