

Emission and Performance Analysis of Re-Entry Combustion Chamber Using Hydrogen Enriched Biodiesel

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Mechanical Engineering

By

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SATHYABAMA

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

Accredited with grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **LINU JOFFIN (Reg. No. 37150106)** and **DERIK LAYOLA (Reg.No. 37150049)** who carried out the project entitled “**EXPERIMENTAL INVESTIGATION ON TOROIDAL PISTON HEADS**” under our supervision from December 2020 to April 2021

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We, **LINU JOFFIN (Reg. No. 37150106)** and **DERIK LAYOLA (Reg.No. 37150049)** hereby declare that the Project Report entitled “**EXPERIMENTAL INVESTIGATION ON TOROIDAL PISTON HEADS**” is a record of an original work done by us under the guidance of **Dr. J. HEMANANDH M.E., Ph.D.**, at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

The quest for alternative energy sources is both urgent and appropriate. Finding sustainable solutions that increase performance while reducing emissions not only decreases dependency on fossil fuel but also increases optimal air quality by reducing harmful emissions. The emphasis is shifting away from fossil fuels due to global carbon emissions and resource depletion. This has resulted in a frantic scramble for alternative energy sources, spanning from wind and solar to biofuel and beyond. Our analysis, which looks at potential biodiesel substitutes, is influenced by this need for alternate energy sources. The aim is to look into the power, durability, combustion, and nature of emissions of a dual fuel engine that uses WVO biodiesel as the primary fuel. As a secondary fuel, hydrogen was injected into the air intake.

The biodiesel blends used in this analysis are Jatropha oil blended with diesel in volume fractions of 20% and 30%, respectively, to produce BV20 and BV30 fuels. At a rate of 4 lpm, hydrogen and air were pumped together. The acquired WVO was converted into useful biodiesel that was used to create the biodiesel blends using the transesterification process. This biodiesel blend's performance and emission results in Re-entrant combustion chamber.

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LIST OF SYMBOLS AND ABBEREVIATION

JBO	Jetropha Oil
JB30 30%	Jetropha Oil Bio Diesel and 70% Pure Diesel
JB20 20%	Jetropha Oil Bio Diesel and 80% Dure Diesel
PD100%	Pure Diesel
4 LPM	Hydrogen Flow Rate liters/min
BSFC	Brake Specific Fuel consumption
BTE	Brake Thermal Efficiency
HRR	Heat Release Rate
CO	Carbon monoxide
CO ₂	Carbon dioxide
NO _x	Nitrogen dioxide

CHAPTER 1

INTRODUCTION

Energy demand has increased tremendously in the past and will increase even more in the coming years in our world. The non-renewable energy of fossil fuels is being reduced at a rapid rate and this fact intensifies the need to look for alternative fuels to meet our energy needs. The energy consumption rate has increased tremendously. Conventional energy resources such as diesel, petroleum, gas and coal will soon be depleted; So there is an urgent need to create alternative sources of fuel. Biodiesel is one of the best alternative and renewable fuels. Biodiesel is renewable, sustainable, and possesses similar properties to those of petroleum diesel. In spite of its favorable attributes, biodiesel owing to its oxygen content, leads to higher NO_x emissions proportional to its inclusion rate in fuel blends. And ways to increase the combustion in the cylinder are been investigated. So by changing the piston geometry there can be a possibility of increasing the combustion rate in the cylinder.

Due to the gradual depletion of world petroleum formation on the injectors, carbon deposits, oil ring reserves and the impact of environmental pollution of sticking and gelling of lubricating oil as a result of increasing exhaust emissions, there is an urgent need for contamination by the vegetable oils. There are different suitable alternative fuels for use in diesel engines. In view methods for reducing viscosity of vegetable oils such as of this, vegetable oil is a promising alternative because it preheating, blending and transesterification. has several advantages; it is renewable, environmentally Jatropa oil has better yield as well as thermophysical friendly and produced easily in rural areas, where there is properties near to diesel fuel. As the edible oil prices are an acute need for modern forms of energy. escalating day by day so that researchers are working on the authors mentioned that the use of non-edible non- edible oils. In this study, the experimental tests are vegetable oils compared to edible oils is very significant conducted on a single cylinder diesel engine using because of the tremendous demand for edible oils as food transesterified Jatropa oil and diesel blended fuel. The and they are far too expensive to be used as fuel at performance parameters like thermal efficiency, specific present. Rapid increase in the prices of

petroleum fuel consumption, volumetric efficiency, brake power and products and harmful exhaust emissions from engines exhaust emission concentrations are determined jointly created renewed interest among researchers to find experimentally. It is concluded that Jatropha oil could be the suitable alternative fuels.

It is concluded that the used as an alternative fuel in the blending form. use of any vegetable oil posses some problems when subjected to prolonged usage in Internal Combustion Experimental Set up and Test Rig: In this study, Engines. These problems are attributed to high viscosity, transesterification of the oil was carried out in the low volatility and polyunsaturated character of neat laboratory using standard procedure. The properties of vegetable oils. High viscosity of vegetable oil causes prepared diesel- biodiesel blends (D100, B20, B60 and some problems in atomization by injector systems and B100) were tested in the laboratory using standard test.

1.1 DIESEL ENGINE

Every internal-combustion engine in which air is compressed to a high enough temperature to ignite diesel fuel pumped into the cylinder, causing combustion and expansion to actuate a piston. It turns the chemical energy in the fuel into mechanical energy that can be used to power freight vehicles, large tractors, locomotives, and ships. A small number of trucks, as well as some electric motor sets, are diesel- powered.

1.1 DIESEL COMBUSTION

The diesel engine is a piston-cylinder unit with intermittent combustion. It has a two- stroke or four-stroke cycle as in Fig 1.2 but, unlike a gasoline engine with spark ignition, the diesel engine only injects air into the combustion chamber on the intake stroke. Compression ratios in diesel engines are usually in the range of 14:1 to 22:1. Engines with bores (cylinder diameters) smaller than 600 mm will have both two-stroke and four-stroke designs (24 inches). Two-stroke cycles are nearly commonly used in engines with bores larger than 600 mm.

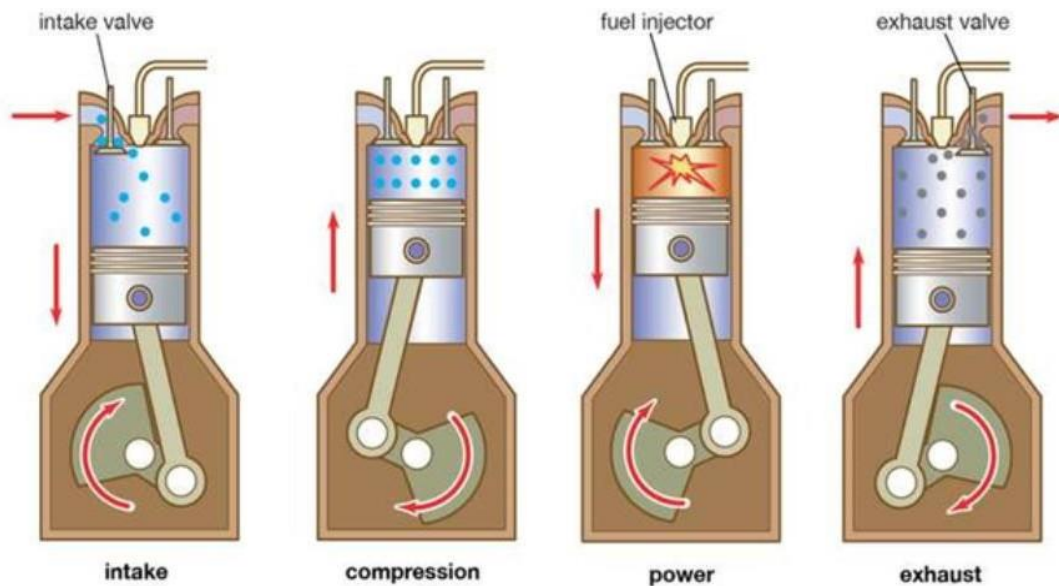


Fig 1.2 Diesel combustion

The diesel engine produces power by burning fuel pumped or sprayed into the cylinder's compressed, hot air charge. The air must be heated to a temperature higher than the ignition temperature of the injected fuel. Carbon sprayed into air with a temperature greater than the fuel's "auto-ignition" temperature naturally interacts with oxygen in the air and burns. The temperature of the air inside the cylinders is measured by both the engine's compression ratio and its current operating temperature; but, at engine start-up, supplemental heating of the cylinders is often used, since the temperature of the air inside the cylinders is determined by both the engine's compression ratio and its current operating temperature. Since combustion is ignited by air heated by friction rather than an electric spark, diesel engines are often referred to as compression-ignition engines. Fuel is introduced into a diesel engine as the piston reaches the top dead centre of the stroke. The fuel is injected into a precombustion chamber or directly into the piston-cylinder combustion chamber under high pressure. Diesel engines, with the exception of compact, high-speed units, use direct injection.

Fuel-injection systems for diesel engines are normally designed to provide injection pressures ranging from 7 to 70 megapascals (1,000 to 10,000 pounds per square inch). There are, however, a few devices with higher pressures.

A diesel engine's output depends on precise fuel injection power. Fuel injection must begin at the correct piston position and the whole combustion process is driven by it (i.e., crank angle). If the piston is near top dead core, the fuel is burnt in a nearly constant-volume phase at first. Fuel injection occurs as the piston travels away from this location, and the combustion mechanism emerges as a virtually constant-pressure process.

In a diesel engine, the combustion process is heterogeneous, which means that the fuel and air are not combined until combustion begins. As a result, fast vaporisation and mixing of the fuel in the air is critical for complete combustion of the injected fuel. Indirect-injection engines, in particular, put a high value on injector nozzle configuration. During the power stroke, the engine produces work. The power stroke encompasses both the constant-pressure combustion phase and the extension of the hot combustion materials since fuel injection has ceased.

Turbocharged and after cooled diesel engines are common. The addition of a turbocharger and after cooler to a diesel engine will increase its performance in terms of both power and efficiency.

The diesel engine's most noteworthy attribute is its performance. The diesel engine is not restricted by the preignition issues that affect high-compression spark-ignition engines because it compresses air rather than using an air-fuel mixture. It should be remembered that the theoretical performance of a spark-ignition engine is greater than that of a compression-ignition engine for a given compression ratio; moreover, compression-ignition engines can be run at compression ratios high enough to yield efficiencies greater than those obtained by spark-ignition systems in operation. Furthermore, diesel engines cannot regulate strength by throttling the intake mixture. As a result, the diesel engine's idling and reduced-power performance is much superior to that of a spark-ignition engine.

Diesel engines' main disadvantage is the pollution they emit into the atmosphere. As compared to spark-ignition engines, these engines usually emit a lot of particulate matter (soot), volatile nitrogen compounds (commonly known as NO_x),

and odour. As a result, customer adoption is poor in the small-engine segment. An external power source is used to start a diesel engine before conditions are developed that allow the engine to run on its own power. The best way to get started is to feed each of the cylinders air from a high-pressure supply (roughly 1.7 to approximately 2.4 megapascals) during their normal firing stroke. The compressed air is sufficiently heated to ignite the fuel. Other auxiliary equipment-based starting methods include providing compressed air to an air-activated motor geared to rotate a large engine's flywheel; supplying electric current to an electric starting motor geared to rotate the engine flywheel; and using a small gasoline engine geared to rotate the engine flywheel. The best starting strategy is determined by the actual scale of the engine to be started, the quality of the attached load, and whether or not the load can be removed when the engine is being started.

1.2 DIESEL ENGINE EFFICIENCY

1.1.1 Carbon Dioxide (CO₂)

The fundamental ozone depleting substance delivered from human exercises is carbon dioxide (CO₂). CO₂ represented around 81.3 percent of all human-caused ozone harming substance outflows in the United States in 2018. As a component of the Earth's carbon cycle, carbon dioxide is really present in the climate. Human activities are modifying the carbon cycle, both by offering more CO₂ to the climate and by influencing regular sinks' ability to concentrate and store CO₂ from the environment, like trees and soils.

The significant result of the hydrocarbon fuel burning is carbon dioxide. With nitrous oxide, methane, perfluorocarbons, sulphur, and hydrofluorocarbons, it is one of the primary greenhouse gas emissions (Kaewmai et al., 2012). CO₂ is as yet found in environment, anyway in exceptionally little fixations. In any case, the level has increased at a remarkable rate after some time. As indicated by global Energy office review, net CO₂ outflows from the fuel burning was practically unimportant in 70's, however were determined to be 33.5Gt CO₂ in 2019. Human practices have changed the harmony and are not, at this point ready to fill in for the timberlands ability to assimilate CO₂. Gigantic utilization of fossil energy

(flammable gas, coal, and oil) on a worldwide scale, compounded by contamination and the long life expectancy of CO₂ in the climate, negatively affects environmental change and is a significant issue for all countries (IEA, 2011). Some of the recommended arrangements incorporate the utilization of motor innovation that give better fuel transformation effectiveness, the utilization of sustainable power, the utilization of low-carbon powers, and, over the long haul, the utilization of hydrogen.

1.1.2 HYDROCARBONS (HC)

Hydrocarbons are unsafe for the environment and for human prosperity. They contribute altogether to the arrangement of ground-level ozone, alongside other poison toxins. Hydrocarbons are destructive and can bother the respiratory framework just as cause malignant growth. Alkanes, alkenes, and aromatics are only a small bunch of the large number of types of hydrocarbons (Hiroyuki et al. 2011).

Unburned hydrocarbons keep on responding in the fumes if the temperature is over 600 °C and oxygen present, so hydrocarbon emanations from the tailpipe might be altogether lower than the hydrocarbons departing the chamber. Hydrocarbon discharges from diesel motors are normally negligible. Diesel hydrocarbon discharges are regularly brought about by light loads. Lean air–fuel blending is the essential driver of light-load hydrocarbon contamination. Fire speeds in lean combinations can be excessively low for burning to finish during the force stroke, or ignition may not happen by any stretch of the imagination, bringing about high hydrocarbon emanations (Zheng et al. 2008). Discharge failure and low charge combination are ascribed to the fixation level because of absence of legitimate fuel and air blending. Oil film layers, divider fire extinguishing, stores and fissure in the burning chamber, fluid fuel, and fumes valve spillage are on the whole potential reasons for HCs emissions. Furthermore, the oil frequently utilized grease up the cylinder rings and chamber liner may prompt the outflow of HCs. The oil dainty film burns-through fuel, preventing it from meddling in the ignition cycle and permitting it to escape unburned from the ignition chamber. To limit HCs emanations, a few techniques, for example, changing fuel infusion speed,

expanding fuel infusion pressure, and changing the cylinder head are utilized to improve blending time and force.

1.1.3 CARBON MONOXIDE (CO)

Carbon monoxide is a non-destructive, unscented, dull, and dismal substance that is harmful to people. CO noticeable all around when breathed in and taken into the circulation system by people. It ties to hemoglobin and keeps it from conveying oxygen. As a result, centre is prevented, reflexes are eased back, and disarray happens (Walsh 2011). It is a side-effect of fragmented copying of carbon-containing fuels. This fixation is for the most part dictated by the air/fuel blend, and it is most noteworthy in rich combinations where the overabundance air factor (λ) is under 1.0. (Wu et al. 2004). Over-blending and under-blending among air and fuel are the two significant reasons for CO framing in diesel motors (Bagal et al., 2009).

To accomplish a sufficient level of contamination control, a few endeavors have been made. Enhancements in motor setup and working conditions, for example, the utilization of fuel infusion timing, burning chamber plan, and ignition cavity width to accomplish uniform air-fuel blending, just as the utilization of oxygenated diesel energizes, are among them (Chen and Iwashina, 2009, Lapuerta et al., 2008a).

1.1.4 NOX EMISSIONS

Three procedures can be utilized to clarify the chance of NOX creation in the ignition chamber i.e, Thermal, NOx arrangement from the fuel, Fenimore NOx development. While the commitment of the principal interaction is viewed as the most significant, of every one of the three NOX arrangement systems (Ban-Weiss et al., 2007). The burning chamber is at first loaded up with air, which is generally comprised of oxygen and nitrogen. To combust the fuel, diesel motors utilize amazingly packed hot air. At that point the fuel is splashed straightforwardly into the packed air in the ignition chamber toward the finish of the pressure stroke. The nitrogen noticeable all around doesn't respond with the oxygen in the burning chamber and is ousted from the motor in a similar way. Nonetheless, high temperatures in the chambers over 1,600 °C permit nitrogen to respond with oxygen,

bringing about NO_x outflows lead to add up to NO_x contamination.

The measure of NO_x discharged is dictated by the chamber's most extreme temperature, oxygen fixations, and warming rate. For a 100 °C ascend in ignition temperature, the volume of NO_x created increments by two-thirds (Lee et al. 2013). Accordingly, the temperature and oxygen fixation in the burning are the main variables in NO_x production. Both NO and NO₂ are harmful, however NO₂ is multiple times more poisonous than NO and is an immediate wellspring of human lung sickness. Nitrogen oxides (NO) and nitrogen dioxide (NO₂) are key things for nitrogen oxides. NO records for 85–95% of NO_x outflows. In the environment, it is ultimately changed to NO₂. Regardless of the way that NO and NO₂ are gathered as NO_x, there are some significant varieties between the two foreign substances.

On account of the unfriendly impacts of NO_x, some NO_x restricting frameworks for inner ignition motors have been acquainted with lessen outflows. less abundance air, denitrogenation of the fuel, start or infusion timing improvement to diminish home time at high in-chamber temperature, synergist ignition or after treatment framework, including the utilization of particular reactant decrease (SCR), and premixed or homogeneous admission charge activity. Since NO_x outflows are emphatically connected to high in-chamber temperatures, a weakened admission charge from one or the other air or fumes gas re-flow (EGR) will altogether diminish emanations.

1.1.4 PARTICULATE MATTER (PM)

Particulate Matter (PM) is a typical motor out contamination from diesel motors, Diesel motors produce significantly more particulate matter (six to multiple times more) than gas motors. Residue, dissolvable natural division (SOF), and inorganic portion (IF) are the three head segments of diesel molecule contaminations. Sediment, which shows

up as dark smoke, represents the greater part of all PM discharges. At the point when motor burdens are low and fumes temperatures are low, SOF esteems are excessively high (Sarvi et al. 2011; Tighe et al. 2012). A non-homogeneous ignition system in the chamber is liable for this. Most of particulates are brought about by inadequate burning of hydrocarbons in gas and lube oil. The sweet-smelling substance of the fuel likewise adds to the measure of PM that is delivered (Xinling and Zhen, 2009). Thus, a fuel with a low sweet-smelling substance can assist with decreasing PM levels.

PM arrangement can be directed by adjusting in-chamber conditions by double fuel burning and changing fuel properties by the utilization of oxygenated and free-sweet-smelling powers.

1.2 MAJOR TYPES OF DIESEL ENGINES

1.2.1 Three basic size groups

Diesel engines are classified into three categories based on their power output: small, medium, and large. The small engines produce less than 188 kilowatts of fuel, or 252 horsepower. This is the most common kind of diesel engine on the market. These motors are used in motorcycles, light vehicles, some agriculture and manufacturing uses, as well as small stationary electrical-power generators (such as those used on pleasure craft) and mechanical drives. They're generally four- or six- cylinder direct-injection engines with four or six cylinders. All of them have turbochargers and aftercoolers.

The power output of medium engines ranges from 188 to 750 kilowatts, or 252 to 1,006 horsepower. Heavy-duty trucks use the bulk of these engines. They're typically six cylinder turbocharged and aftercooled direct-injection engines. This size category also includes several V-8 and V-12 engines. Large diesel engines can produce up to 750 kilowatts of fuel. These one-of-a-kind engines are used in marine, locomotive, mechanical drive, and electrical-power generation applications. Direct-injection, turbocharged, and aftercooled systems are

the most popular. When stability and endurance are important, they can run at as low as 500 revolutions per minute.

1.3 TWO-STROKE AND FOUR-STROKE ENGINES

Diesel engines, as previously mentioned, can run on either a two- or four-stroke cycle. The intake and exhaust valves, as well as the fuel-injection nozzle, are all situated in the cylinder head of a traditional four-stroke engine. Dual valve configurations are sometimes used, with two intake and two exhaust valves.

The two-stroke cycle can be used to remove one or both valves from the engine configuration. The cylinder liner usually has ports for scavenging and intake air. Exhaust may be routed by cylinder head valves or cylinder liner ports. The use of a port configuration rather than one having exhaust valves simplifies engine development.

1.4 SUBSEQUENT DEVELOPMENTS AND APPLICATIONS

For marine propulsion, several diesel engines were ordered. The diesels, on the other hand, typically rotated quicker than was ideal for large ship propellers since the high speeds of the massive propellers appeared to produce hollowed-out regions within the water surrounding the propeller (cavitation), resulting in thrust loss. Smaller propellers, on the other hand, did not have this problem, and diesel engines proved to be particularly ideal for yachts where speed is required. The problem was overcome by using a diesel-electric system, in which the turbines were connected to direct-current generators, which supplied the electricity to power an electric motor mounted to the ship's propeller. There were also several installations where the diesel was attached to the propeller either directly or by gears. Diesel engines with higher horsepower and slower rotating speeds were mounted in freight and passenger ships when they became affordable.

The diesel engine became the predominant power plant for military equipment on the ground and at sea during World War II. Since then it has been adopted for use in heavy construction machinery, high-powered farm tractors, and most large trucks and buses. Diesel engines also have been installed in hospitals, telephone exchanges, airports, and various other facilities to provide emergency

power during electrical power outages. In addition, they have been used in automobiles, albeit on a limited scale. Although diesels provide better fuel economy than gasoline engines, they do not run as smoothly as the latter and emit higher levels of pollutants.

1.5 HISTORY OF BIODIESEL FUEL

The diesel engine, invented by Rudolph Diesel in the 1890s, has been the engine of choice for efficiency, reliability, and high fuel economy all over the world. The French government and Dr . Diesel himself were among the first to experiment with vegetable oil fuels, believing that pure vegetable oils could power early diesel engines for agriculture in distant parts of the world where petroleum was unavailable. Modern biodiesel fuel, which is produced by converting vegetable oils into fatty acid methyl esters, has its beginnings in Belgian research from the 1930s, but the European biodiesel industry did not emerge until the late 1980s.

The diesel engine was built in response to a need to build on the late 1800s' slow, sluggish, and often dangerous steam engines. The compression ignition theory refers to diesel engines, which ensures fuel is pumped into the cylinder after air has been heated to a high pressure and temperature. The fire self-ignites and burns quickly as it reaches the cylinder, pulling the piston back down and turning the chemical energy in the fuel to mechanical energy. The first compression ignition engine patent was granted in 1893 to Dr .Rudolph Diesel, after whom the engine is named. Diesel's ingenious engine, which could run on a range of fuels, made him famous all over the world.

1.6 EARLY WORK

Early diesel engines had complicated injection systems and were designed to run on a variety of fuels, including kerosene and coal dust. It was only a matter of time before someone realised that vegetable oils would make excellent fuel due to their high energy content. At the 1900 World's Fair, the French government ordered the Otto company to develop a diesel engine that ran on peanut oil, which was the first public demonstration of vegetable oil-based diesel fuel. Vegetable oils piqued the French government's curiosity as a domestic fuel for their African colonies. Rudolph Diesel went on to do a lot of research on vegetable oil fuels and became

a big supporter of the idea, claiming that farmers would profit from having their own petrol. However, it would be almost a century before such a concept became widely accepted. Petroleum became commonly available in a number of ways shortly after Dr. Diesel's death in 1913, including the class of gasoline we currently call "diesel fuel." Due to the availability and low cost of petroleum, the diesel engine design was modified to match the properties of petroleum diesel fuel. As a result, a fuel-efficient and powerful engine was developed. Diesel engines would become the industry standard for the next 80 years as fuel, economy, and durability were needed.

1.7 MODERN ENGINE, MODERN FUEL

Vegetable oil-based fuels received little exposure due to the widespread supply and low cost of petroleum diesel fuel, even at periods of high oil prices and shortages. During WWII and the 1970s oil shortages, there was a brief surge of interest in using vegetable oils to power diesel engines. Unfortunately, owing to the much higher viscosity of vegetable oil relative to conventional diesel fuel, newer diesel engine designs do not work on typical vegetable oils. It was necessary to find a way to reduce the viscosity of vegetable oils so that they could be burnt properly in a diesel engine. Pyrolysis, solvent mixing, and even emulsifying the fuel with water or alcohols have all been suggested as ways to accomplish this mission, but none of them have proved to be successful. In 1937, a Belgian inventor suggested using transesterification to convert vegetable oils into fatty acid alkyl esters and use them as a substitute for diesel fuel. Transesterification is a process that breaks down vegetable oil into three smaller molecules that are less viscous and simpler to burn in a diesel engine. Modern biodiesel is made from fatty acid methyl esters, and the transesterification reaction is the key to its processing. Concerns regarding the atmosphere, energy stability, and agricultural overproduction resurfaced in the early 1980s, triggering the use of vegetable oils once more, this time with transesterification as the favoured way of manufacturing such fuel substitutes.

1.8 THE FUTURE OF BIODIESEL FUEL

Biodiesel is rapidly becoming one of the world's fastest growing renewable fuels due to its low emissions profile, ease of use, and many other advantages. Biodiesel is cost competitive with petroleum diesel with nominal subsidies, and

millions of consumers have discovered and appreciated the benefits of the gasoline. Biodiesel's potential depends on the world's ability to generate green feedstocks including vegetable oils and fats at a cost that is comparable with petroleum, without displacing land used for food processing or damaging natural habitats. Producing biodiesel in a sustainable manner would make this clean, green, and cost-effective fuel to assist the world in dealing with rising petroleum shortages while still offering economic and environmental benefits long into the twenty-first century.

1.9 HYDROGEN AS FUEL

It is important that a fuel should be used in all situations. When we compare fuels, we can see that each one is used for a specific purpose. Alternative resources are gaining traction as fossil fuels become scarce and create a slew of problems. It is important to use hydrogen as a fuel because it can be derived from a range of sources and is environmentally sustainable and long-lasting.

Just water is emitted as a result of the burning of hydrogen, a renewable fuel. Because of the nitrogen and oxygen in the air, NO_x is formed when combustion occurs at high temperatures. This dilemma exists with other fuels as well, and it can be addressed in a variety of ways. Unlike other fuels, though, hydrogen is not a pollutant that can damage the environment. The formation of CO₂, HC, and CO, which are known as toxins, does not exist because hydrogen has no carbon in its composition.

As hydrogen - fueled engines become more advanced, unhealthy combustion emissions from cars and the volume of CO₂ released into the atmosphere, which contributes to global warming, will decrease. While hydrogen has a high thermal value, its thermal value per volume is low because it has a low density relative to air. Reduced volumetric performance, particularly where hydrogen is used in pre-mixed engines, as well as reductions in motor strength and torque, result from this. The laminar combustion rate of a mixture of air and hydrogen is ten times higher than gasoline under stoichiometric conditions.

Combustion improves and performance improves as hydrogen has a high combustion rate and decreases the amount of heat lost by heat transfer. Furthermore, we do not consider toxic soot to be a by-product. The high rate of

combustion of hydrogen increases the volume of NO_x produced as well as the sound of combustion. If hydrogen is to be used as the primary fuel in automobiles, a greater storage tank would be needed to ensure adequate range.

The hydrogen-air mixture burns in the 4e75 percent air by volume band, which is a reasonably wide combustion range. Fuel economy is guaranteed when these broad limits are taken into consideration, since combustion is accomplished with a weak mixture. Since the temperature does not increase significantly at the end of the combustion of the lean blend, the NO_x content is minimised.

Since hydrogen's self-ignition temperature (584.4°C) is greater than that of gasoline and natural gas, it would need an internal supply when used in internal combustion engines. The ability of internal combustion engines to improve performance by increasing the compression ratio is one of their most significant features. The performance of these engines can be improved by achieving higher compression speeds due to the high self-ignition temperature of hydrogen. However, since hydrogen's flame extinction distance is less than that of gasoline and natural gas, flame recovery is more possible. Furthermore, at stoichiometric and ambient pressure, the combustion rate of hydrogen is 2.83m/s, while the combustion rate of gasoline is 0.3m/s. Since the ignition time and advance for fast-burning fuels should be more sensitive, certain changes to the current system should be made.

1.10 USING HYDROGEN IN ENGINES

Hydrogen can be used as a fuel in internal combustion engines or to power electric motors in fuel cells. Unlike the direct use of hydrogen in internal combustion engines, the combustion form of the fuel can be changed with minor modifications to the combustion mechanism. The way hydrogen enters the combustion chamber of the engine has been realised through injection or carburettor devices from the premixed manifold in several experiments on the use of hydrogen in internal combustion gasoline engines in the automotive industry. Hydrogen is an effective fuel for internal combustion engines since it has a high ignition temperature and can be used at high compression rates. Hydrogen can be used as a direct fuel in gasoline engine injection systems due

to its structural properties. When hydrogen is used as a fuel in internal combustion engines, spark plugs with a smaller energy potential are used. As gasoline is used as the fuel in internal combustion engines, power is limited by knocking; however, when hydrogen is used as the fuel, power is limited by early ignition.

1.11 USE OF HYDROGEN AS A SECONDARY FUEL

There are two ways to use hydrogen in internal combustion engines. The first method is used as a sole fuel source, while the second method is used as a substitute. Despite the fact that there are certain issues with using hydrogen as a single fuel, research continues. The most serious issues are flash back, early combustion, and knocking, which are caused by the compression ratio and temperature. Another significant issue is that, despite the limited volume of hydrogen contained, the storage equipment is heavy. This increases the vehicle's modifications and additional costs. In the current case, adding hydrogen to the fuel of internal combustion engines might be a more effective process. While the reliance on fossil fuels does not vanish when this process is used, hydrogen will be used in conjunction with an industrial transition in the fuel system, and toxic exhaust emissions will be eliminated at the end of combustion. Hydrogen fuel is used in a different way than petroleum and diesel fuel. It can be used in engines with various combustion strategies as a hydrogen-rich gas produced by restructuring carbon and alcohol-based fuels. A reactor system that reconstructs the primary fuel must be mounted on the vehicle for this to happen. With this process, lower ignition energy is obtained with heat recovery by taking advantage of the exhaust gases released by the engine, and harmful emissions are minimised. The use of hydrogen as a complement to other fuels would act as a bridge to the exclusive use of hydrogen as an alternative fuel.

CHAPTER 2

LITERATURE REVIEW

Biodiesel's worth as a maintainable and industrially practical option in contrast to fossil diesel for use in pressure start (CI) motors has provoked broad examination in the course of the most recent twenty years. This is generally because of the shortage of oil supplies and the public comprehension of the natural and wellbeing outcomes of fossil diesel burning.

[1] A. A. Refaat and N. K. Attia (2018). in an examination said that the yield rate acquired utilizing a 6:1 methanol/oil molar proportion, 1% potassium hydroxide as impetus, and a temperature of 65°C for 60 minutes. Under ideal conditions, the yield rate got from squander vegetable oil was equivalent to that acquired from flawless vegetable oil, which arrived at 96.15 %.

[2] Madhu Agarwal and Garima Chauhan (2012), said in the investigation that utilizing potassium hydroxide (KOH) as a homogeneous impetus At the ideal response states of response temperature 70 °C, response time 2 h, impetus fixation 5%, impetus stacking 15% wt%, and methanol to oil molar proportion 9:1, a yield of 96.8% unsaturated fat methyl ester (FAME) was acquired with heterogeneous impetus, while 98.2% yield was gotten with homogeneous KOH impetus at the ideal response states of response temperature 70 °C, response time 2 h, impetus focus KOH stacked on an alumina impetus gave a reasonable respect up to three cycles.

[3] In the examination directed by Murat Kadir Yesilyurt (2019) showed that the waste vegetable oil Biodiesel fuel diminished motor force, slowing down speed, CO, UHC, and smoke murkiness, however improved brake explicit fuel utilization, fumes gas temperature, NOX, and CO₂ emanations. Expanded infusion pressure, then again, came about in up to 210 bar expansions in motor forces, slowing down powers, and brake warm efficiencies. As the discoveries were examined, the ideal fuel infusion pressure for WCOB and fuel mixes was found to be 210 bar.

[4] While K.A. Abed, A.K. El Morsi (2018) said Waste cooking-oil biodiesel mixes would do well to warm efficiencies than diesel oil. Biodiesel mixes had higher explicit fuel utilization than diesel fuel. When contrasting biodiesel mixes with diesel

oil, higher fumes gas temperatures were noticed. CO₂ emanations were higher for squander cooking-oil biodiesel mixes than for diesel oil. Biodiesel mixes had lower CO, smoke haziness, and HC emanations than diesel fuel. Biodiesel mixes had higher NO_x exminations than diesel fuel.

[5] It was found in examination by Qing shu and jixian Gao(2010) that squander vegetable oil with undeniable degrees of free unsaturated fats (FFAs). When utilizing a 16.8 M proportion of methanol to oil and 0.2 wt. percent of impetus to oil, the greatest transformation of fatty oil and FFA was 80.5 wt. percent and 94.8 wt. percent after 4.5 hours at 220°C. and

[6] Furthermore by Suleyman Simsek and Samet Uslu that with the utilization of AFBD100 and VEBD100 powers, the brake warm effectiveness (BTHE) esteem diminished while the brake explicit fuel utilization (BSFC) expanded. At the point when examined as far as fumes discharge results, the decrease of carbon monoxide (CO), hydrocarbon (HC) and smoke emanations contrasted with D100 was dictated by the utilization of AFBD100 and VEBD100 powers, while an increment in nitrogen oxide (NO_x) and carbon dioxide (CO₂) outflows happened.

[7] Mustafa Atakan Akar et.al(2018) tracked down that The expansion of hydrogen to investigate fuel watse vegetable oil improved effectiveness and outflow measurements while expanding NO_x discharges. At the point when test fills were advanced with hydrogen gas, brake warm proficiency and fundamental fuel utilization expanded. Hydrogen fuse diminished CO and CO₂ discharges because of the absence of carbon molecules in the substance arrangement of hydrogen fuel, however raised chamber temperature caused an ascent in NO_x outflows.

[8] M channappagoudra et.al,(2018) found that motor working on a 20% mix of dairy rubbish oil biodiesel, the hemispherical cylinder bowl calculation (HPBG) of a current diesel motor was changed to toroidal cylinder bowl math (TPBG) . In response to the motor change, the test discoveries showed improved brake warm effectiveness and warmth discharge pace of 5.5 % and 17.24 %, individually, while brake explicit fuel utilization, HC emanation, and CO outflow were decreased by 8.75 percent, 15%, and 14.47 percent, separately. Improved fuel atomization,

diminished fuel bead size, expanded chamber temperature, improved crush and whirl, and different benefits of utilizing the TPBG may all be credited to it.

[9] In investigation directed by prabhakara rao et.al, (2016) on impact of cylinder bowl math on the exhibition and emanations of DI diesel motor, The TCC cylinder bowl calculation made a more grounded air–fuel blend inside the chamber, bringing about a more homogeneous charge. Besides, by changing the profundity of the bowl. The case with a 1.26 mm decrease in bowl profundity from the pattern (TCC) particular has the most noteworthy outflows and productivity qualities of the relative multitude of cases.

[10] U S Jyothi et.al,(2020) infers that on account of Toroidal cylinder calculation, the base molecule width is somewhat bigger than hemispheric structure toward the finish of the infusion cycle at 365.250 CA. With hydrogen supplementation, it is additionally brought down to an alluring degree of around 6%. This is because of the expansion of hydrogen to the carbon material, which helps the ignition cycle by raising the chamber temperature. On the off chance that the infusion progresses from 341.50 CA to 365.250 CA with hydrogen supplement, the general molecule breadth increments concerning bowl calculations in hemispherical, toroidal, and re-participant toroidal structures, separately, instead of perfect diesel alone.

[11] Rahul Banerjee et.al, (2012) found that correlation with diesel activity, 20 % cooled EGR under hydrogen advancement revealed a decrease of 9.2 % and 12.3 % in NO_x outflows at 60 % and 80 % load, separately, while holding a decrease of 4.6 % and 1.9 % in brake explicit energy utilization, just as a 10 % and 8.33 % identical diminishing in brake explicit energy utilization. CO emanations were diminished by 26.6 % and 20.0 %, separately, while CO₂ discharges were decreased by 24.5 % and 29.1 %, while brake warm execution was improved by 4.8 % and 2 %, and fundamental fuel utilization (SFC) was decreased by 23.3 % and 18.95 %.

[12] N.Saravanan and G.Nagarajan said in an examination that hydrogen acceptance to the diesel motor Using the carburation strategy, explicit energy admission, NO_x emanations, and fumes gas temperature rose by 6%, 8%, and 14

percent, individually, while brake warm effectiveness and smoke level diminished by 5% and 8%, separately, when contrasted with pattern diesel. Additionally said that while utilizing Timed port infusion procedure the brake explicit energy utilization, temperature of the fumes gas, and the measure of smoke radiated were totally diminished by 15%, 45%, and 18 percent, individually. In contrast with benchmark diesel, brake warm proficiency and NO_x improved by 17% and 34%, separately.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

Focal point of the examination is to investigate the discharges and execution of re-entry ignition chamber as shown in Fig 3.1, when utilizing a double fuel mix of biodiesel and Hydrogen at different burdens. The investigation plans to feature the impact that infused Hydrogen has on scaling back of hazardous outflows and improving motor execution across every one of the heaps. This notwithstanding the utilization of a specially made biodiesel mix investigates the chance of utilizing such fuel in regular diesel motors on a more noteworthy, more business scale.

3.2 SCOPE

Our examination, which takes a gander at potential biodiesel substitutes, is formed by this requirement for extra fuel sources. The objective is to investigate the force, strength, ignition, and nature of discharges of a double fuel motor that utilizes JBO biodiesel as the essential fuel. As a strengthening fuel, hydrogen was siphoned into the air consumption. The biodiesel mixes utilized in this examination are JBO mixed with diesel in volume parts of 20% and 30% to create JB20 and JB30, separately. Execution and discharges principles of this fuel were tried with an end goal to track down the most ideal results.

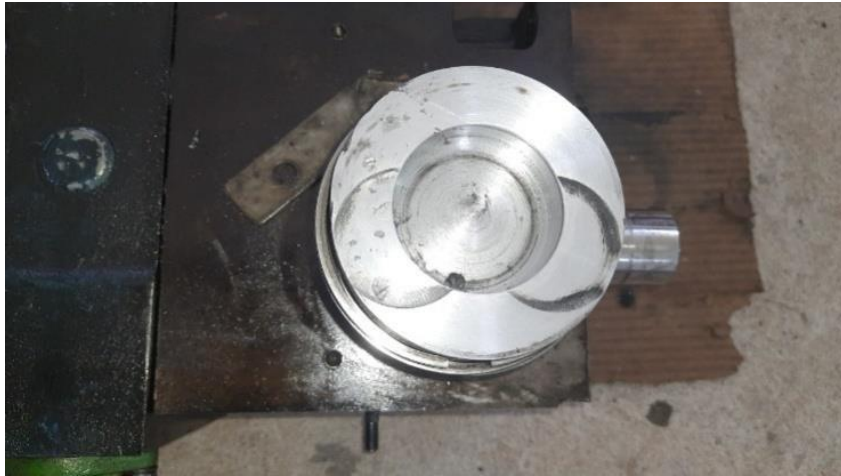


Fig 3.1 Re-entry piston

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 TEST ENGINE

The test motor utilized shown in Fig 4.1, was single chamber direct infusion and normally suctioned 4 stroke diesel motor. The double fuel mode was embraced to a solitary chambers diesel motor. Table records the motor particulars. During the pull stroke, pilot fuel diesel was infused into the burning chamber at 23° BTDC. At 4.5° BTDC, the gulf valve opened and shut down at 35.5° ABDC. At 35.5° BBDC, the fumes valve opened and shut down at 4.5° ATDC. By means of the admission, essential fuel (hydrogen) was blended in with air. The motor is furnished with water cooled whirlpool momentum and utilized for stacking the motor.



Fig: 4.1 Engine Setup

4.2 DYNAMOMETER:

A dynamometer, or "dyno" for short, is a gadget for estimating power, snapshot of power (force), or force. For instance, the force created by a motor, engine or other turning main player can be determined by at the same time estimating force and rotational speed (rpm).

A dynamometer can likewise be utilized to decide the force and force needed to work a determined machine like a siphon. All things considered, a motoring or driving dynamometer is utilized. A dynamometer that is intended to be driven is called a retention or latent dynamometer. A dynamometer that can either drive or ingest is known as a widespread or dynamic dynamometer.

4.1.1 Applications for Dynamometers:

As well as being utilized to decide the force or force qualities of a machine under test (MUT), dynamometers are utilized in various different jobs. In standard discharges testing cycles, for example, those characterized by the US Environmental Protection Agency (US EPA), dynamometers are utilized to give mimicked street stacking of either the motor (utilizing a motor dynamometer) or full powertrain (utilizing a body dynamometer). Truth be told, past basic force and force estimations, dynamometers can be utilized as a component of a test bed for an assortment of motor advancement exercises, for example, the alignment of motor administration regulators, point by point examinations concerning burning conduct and tribology.

In a motor dynamometer, water stream, corresponding to the ideal applied burden, makes protection from the motor. A controlled water move through the gulf complex is aimed at the focal point of the rotor in every retention segment. This water is then ousted to the external dynamometer body by outward power. As it is coordinated outward, the water is sped up into pockets on the fixed stator plates where it is decelerated. The persistent speed increase and deceleration makes the dynamometer assimilate the force delivered by the motor. Through this exchange of energy the water is warmed and released. A fundamental segment of a dynamometer is its information securing framework. The framework is ordinarily

included two units, a Commander and Workstation, associated by an Ethernet link. The Commander, a personal computer worked by Windows-based programming, issues orders to the Workstation, a touch- screen worked unit housed in a tough mechanical walled in area. The Workstation works the accuracy burden and choke control frameworks, gathers the information, and sends it to the Commander to be prepared, put away and broke down.

The Workstation's prosperity, and consequently the information procurement framework's exactness, relies upon its capacity to accurately gauge information in the dynamometer tests. Integral to these estimations is the accuracy of its pressing factor transducers, which measure wind stream in the admission complex, oil pressure and other liquid pressing factors. The administrator is keen on various pressing factors of liquids so having the capacity of acquiring various pressing factors while running the motor is vital.

4.2 DUEL FUEL ENGINE SETUP

The admission air complex has been changed to empower the combination of air and hydrogen into the ignition chamber while the diesel fuel is straightforwardly infused into the burning chamber. A stream meter was prepared to control the measure of hydrogen into the burning chamber.

4.3 ENGINE INSTRUMENTATION

The situation of the driving rod was recorded by utilizing wrench point sensor (Kuebler – Germany). In chamber pressure was estimated utilizing a pressing factor transducer mounted inside the chamber head and associated with the information obtaining board through charge speaker. IC Engine programming was utilized to gather the ignition investigation data. The pace of warmth discharge (ROHR), estimations of demonstrated mean viable pressing factor (IMEP), top in-chamber pressing factor, and rate coefficient of change of IMEP and other typical burning boundaries were among the aftereffects of the investigation of continuous motor cycles (from at least 200 cycles).

4.4 ENGINE OUT EMISIONS MEASUREMENT

An AVL Di-gas analyzer was utilized to gauge the emanations. Carbon monoxide and carbon dioxide are estimated in the analyzer utilizing Non dispersive Infrared (NDIR) sensor innovation. Hydrocarbons are estimated utilizing Flame ionization identifier. NO_x discharges are estimated utilizing the chemiluminescence detector. A temperature managed warmed line is utilized to send the motors outflows to the Di gas analyzer to evade buildup.

4.5 TRANSESTERIFICATION PROCESS:

As obtained in the test carried out on the jatropha oil, it was disclosed that the free fatty acid (FFA) contents of oil are high (21.6%). Hence, it became necessary to reduce it. Procedure. Crude jatropha oil was poured into a conical flask and heated to a temperature of 60°C. A mixture of concentrated H₂SO₄ (1% w/w) with methanol (30% v/v) was heated separately at (50°C) and then added to the heated oil in the flask. The mixture was stirred for 1 hour and allowed to settle for 2 hours. 10.5mL of jatropha oil was measured and poured into 250 mL conical flask and heated to a temperature of 50°C. A quantity of methanol was poured in a round bottom flask and soxhlet apparatus, and the heater was turned on. This was done to purify the methanol. The sodium hydroxide pellet was placed in the weighing balance to get exactly 0.25 g. A solution of potassium methoxide was prepared in a 250 mL beaker using 0.25 g (i.e., catalyst concentration of 0.5%) of sodium hydroxide pellet and 63mL (i.e., mole ratio of oil to methanol of 1:6) of methanol. The solution was properly stirred until potassium hydroxide pellet was completely dissolved. The potassium methoxide solution was placed in the oven to bring its temperature to 60°C. The potassium methoxide solution was then poured into the warm jatropha oil and stirred vigorously for 50 minutes using a magnetic stirrer. The mixture was then allowed to settle for 24 hours in a separating funnel. The biodiesel was then poured into a separate beaker, while the lower layer (which comprises of glycerol and soap) was collected from the bottom of the separating funnel. Warm water was then used to wash the biodiesel to remove any excess glycerol and soap that remain in the funnel. This was done until the clear water was seen below the biodiesel in the separating funnel. The washed sample was dried by

placing it on a hot plate and excess water still in the biodiesel was removed. The quantity of biodiesel. Collected was measured and recorded. The above procedures were repeated by varying the mole ratio of jatropha and methanol, while keeping catalyst concentration, stirring time, and temperature constant

4.6 JATROPHA OIL AND HYDROGEN AS FUEL

For testing, we converted the jatropha oil into biodiesel, where we used JB30 (30% biodiesel + 70% pure diesel), JB20 (20% biodiesel + 80% pure diesel), and hydrogen gas as secondary fuel. At first the engine was fueled with pure diesel, and on subsequent runs it was fueled with pure diesel + 4 LPM H₂ and biodiesel blends and 4 LPM H₂.

4.6.1 Procedure

We have taken the emission, performance, combustion data for the different loads and engine fueled with different biodiesel blends along with H₂ as the secondary fuel.

The emission data was taken from the five gas analyzer and smoke values are taken from the smoke meter. The specs of gas analyzer and smoke meter are given.

Tests were conducted with four different types of fuel blends (pure diesel, pure diesel with 4lpm H₂, JB20 with 4lpm H₂, JB30 with 4lpm H₂) and at values are taken at five different load conditions (0%, 25%, 50 %, 75%, 100%) fuel was injected at a pressure of 200bar with the help of two hole nozzle, and the hydrogen was injected into the air flow passage at the rate of 4LPM.

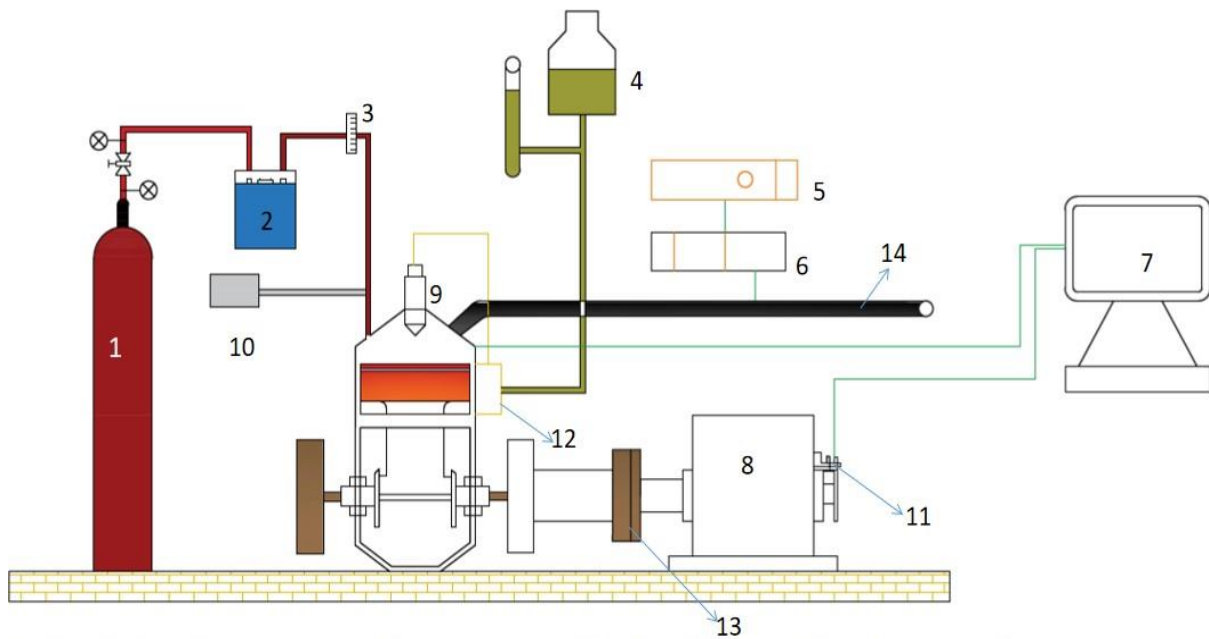
Initially the first tests were performed with the hemispherical piston and the pure diesel the performance, combustion and emission data were taken. Then the piston geometry was changed from the hemispherical piston to re-entered piston. the geometry and the combustion, performance, emission data were taken with the engine fueled with pure diesel. The specifications of test are mentioned in below Table 4.1.

After the engine with re-entered piston geometry was fueled with pure diesel and the intake air was enriched by the supply of H₂ into the neck of air intake chamber.

Table 4.1 specifications of test engine

Type	Single cylinder, four stroke Vertical diesel engine
Stroke length	110mm
Number of cylinders	1
Bore	87.5mm
Number of valves	2
Swept volume	661cc
Compression ratio	17.5:1
Injection pressure	200 Bar
Loading device	Eddy current dynamometer (water cooled)
Dynamometer arm length	195mm

fuel the engine with two fuels, namely diesel fuel and hydrogen as secondary fuels. Hydrogen fuel is supplied from the hydrogen tank Hydrogen gas is supplied at the desired pressure by adjusting the pressure valves, and then the gas is sent through the flame arrestor. The function of the flame arrestor is to extinguish the flame. After coming out of the flame arrestor, hydrogen gas is sent through the flow meter, where we adjust the flow to 4lpm for the engine. The fresh air and diesel fuel at the neck of the hydrogen gas intake chamber mix with the pressure exerted by the 200 bar in the cylinder from the diesel tank. The water-cooled AD current dynamometer is used to apply loads to the engine at five different loads (0%, 25%, 50%, 75%, 100%) and the values of emission, combustion data, and performance are taken. We did experiments with three different combination fuels with hydrogen in the same process. The values of smoke, CO, HC, O₂, and NO_x were taken, and the time taken for 10 ml of diesel consumption to calculate the brake specific fuel consumption was also taken.



1. H₂ cylinder 2. Flame Arrestor 3. Flow meter 4. Diesel Tank 5. Five Gas Analyser 6. Smoke Analyser
7. Computer 8. Eddy Current Dynamometer 9. Fuel injector 10. Intake Air Box 11. Angle Encoder
12. Fuel pump 13. Coupling 14. Exhaust gas Outlet

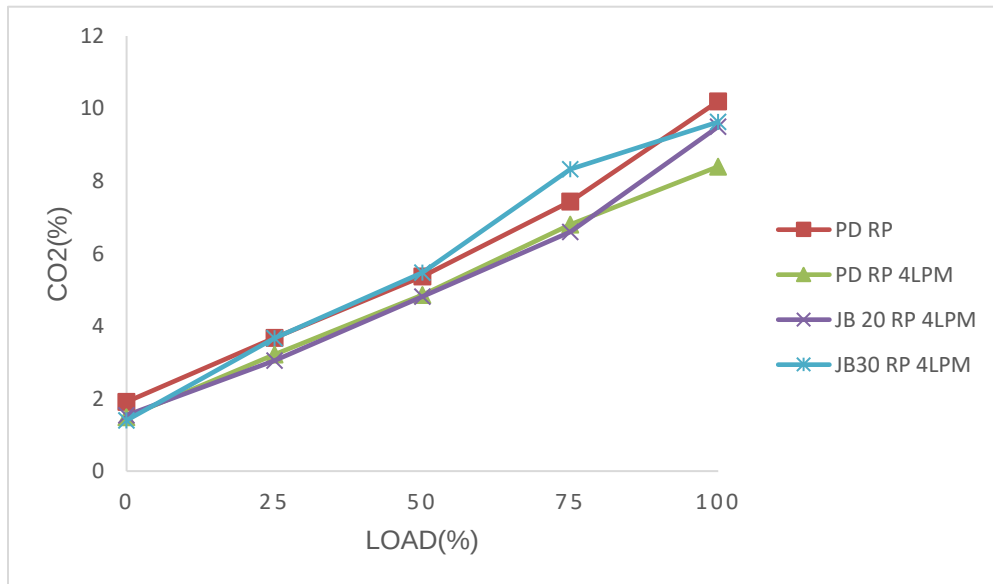
Fig 4.2 schematic representation of Experimental Setup

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Carbon Dioxide Emissions

Carbon dioxide emissions are the main cause of global climate change. We obtained CO₂ as a result of complete combustion of carbon and oxygen in petroleum- based fuels in our tests. Fig 5.1 depicts the influence of hydrogen addition on CO₂ emissions. For each test, CO₂ emissions rose as the engine load was increased. CO₂ emissions decreased as hydrogen was added to biodiesel blends, as seen in Fig. The addition of hydrogen to pure diesel and JB20 biodiesel blends lowered CO₂ emissions, while the addition of hydrogen to JB20 biodiesel blends resulted in a substantial reduction in emissions. JB20 biodiesel blend of 4lpm outperforms plain diesel. The CO₂ emissions from 4lpm Hydrogen is somewhat lower. The lack of carbon that comes with the injection of 4lpm H₂ is the cause for the reduction of CO₂ emissions, rendering the operation even cleaner and the engine much more powerful.



5.1 Comparative analysis CO₂ Emission with load

5.2 Carbon monoxide emissions

Carbon monoxide is one of the most harmful substances to the environment. CO was developed in our tests as a result of partial oxidation of carbon present in JB20 biodiesel during combustion. CO emissions for JB20 and JB30 biodiesel blends with 4lpm Hydrogen were lower in comparison to pure diesel, as seen in Fig 5.2. The explanation for decreased CO emissions is again due to the reduction of carbon produced by the injection of 4lpm Hydrogen, as it was in the case of Carbon dioxide emissions. However, owing to lubrication oil combustion, partial CO remains can be found remaining in engine exhaust.

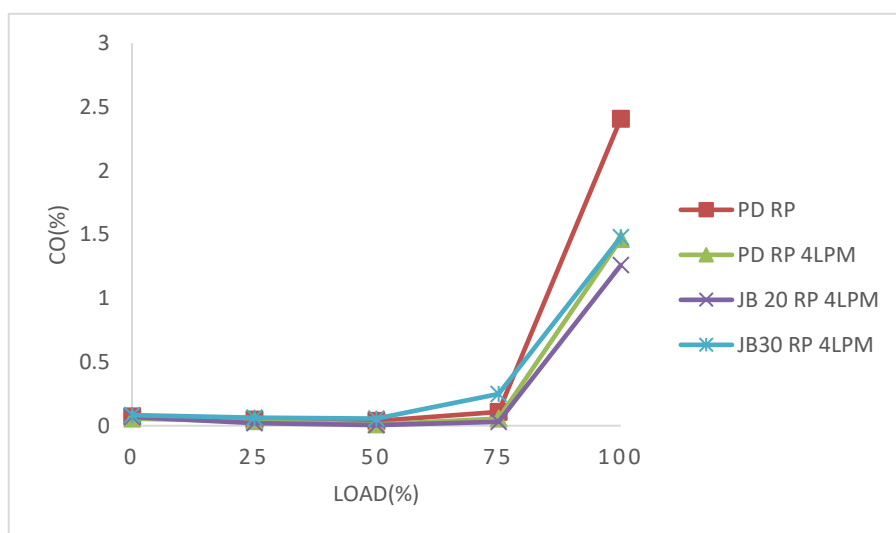


Fig 5.2 Comparative analysis Carbon monoxide emission with load

5.3 NO_x emissions

One of the most dangerous pollution emitted by CI engines is NO_x. It has a NO content of 90-95 % and a NO₂ content of 5-10 %. Higher combustion temperatures, oxygen content in the combustion chamber, and nitrogen exposure at high temperatures all contribute to NO_x emissions. According to Fig 5.3. As compared to pure diesel with 4lpm hydrogen, NO_x emissions increase with the use of JB20 biodiesel blend with 4lpm hydrogen. More fuel was burnt as the engine load rose, resulting in higher temperatures and higher NO_x emissions.

In literature review, it was found that with the use of biodiesel NO_x emissions also increased because of the oxygen content of the biodiesel and the higher cylinder temperatures. Ignition delay is hypothesized as another reason for this NO_x increment.

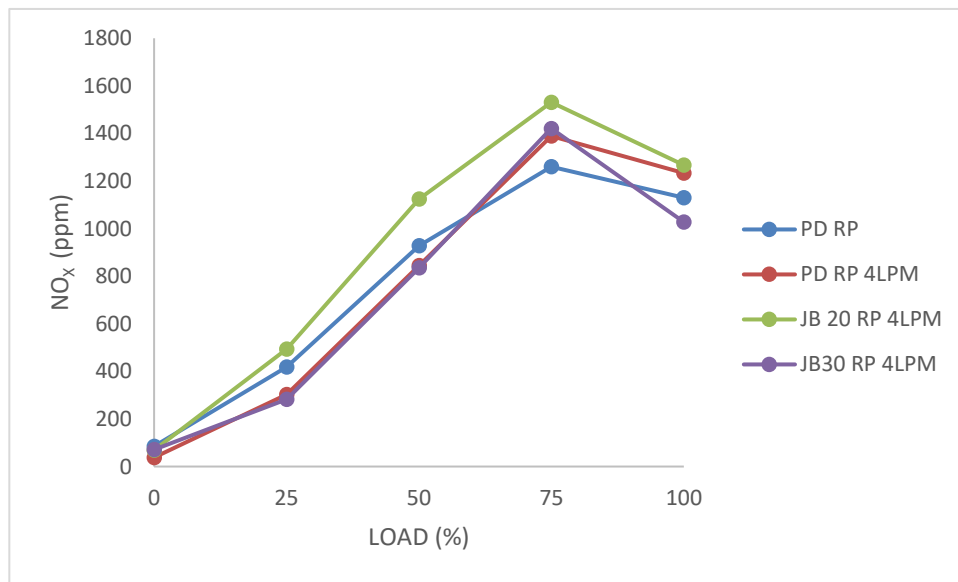


Fig 5.3 Comparative analysis NO_x emissions with load

5.4 Hydrocarbon emission

The incomplete combustion of the fuel results in HC emissions. Hydrocarbon (HC) emissions are gases that are not normally burnt. Since the combustion process proceeds quickly, any unburned fuel can remain in the combustion chamber and be expelled via the exhaust pipe. The effect of these gases is depicted in Fig 5.4. HC emissions increased with increasing engine load in both studies, according to the data. In 4lpm Hydrogen samples, HC emissions were lower with JB20 biodiesel than with pure diesel.

The addition of hydrogen will reduce HC emissions, according to the literature, and the explanation for this is that hydrogen does not contain any carbon molecules. According to the report, HC emissions increased as hydrogen levels increased. The reduction in Oxygen in the cylinders was said to be the most possible source of this rise. As more hydrogen is burnt with biodiesel, the amount of oxygen available decreases.

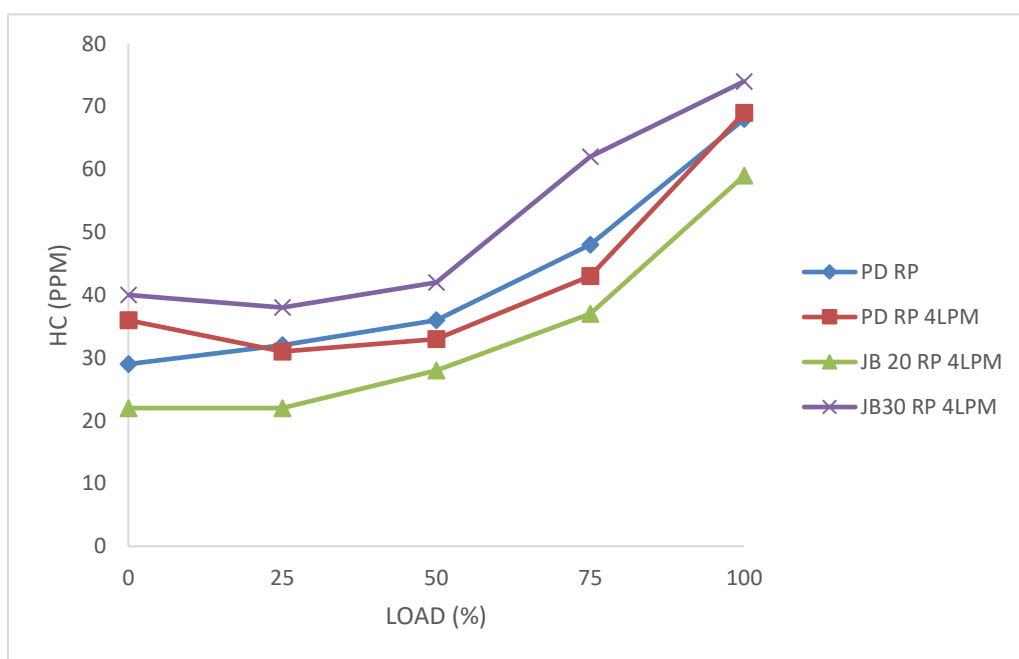


Fig 5.4. Comparative analysis HC emission with load

5.5 Soot emissions

In any ICE, leftover fuel in the form of smoke and soot results from gasoline that has not been fully burned. The formation of soot is common where some hydrocarbon fuel is used in an ICE, and the smoke emissions from JB20 and JB30[30] are comparatively high. Figure 12 shows the difference in smoke levels from pure diesel as opposed to the use of JB20 and JB30.

When compared to emissions emitted by pure diesel, JB20 with 4lpm H₂ and JB30 with 4lpm H₂ produced slight increase of emissions in each load. The reduction in emissions continues as air is enriched with H₂ at various loads. In the other side, as the load rises, so do the smoke emissions in a linear pattern. This increase is due to higher fuel consumption as the engine load increases.

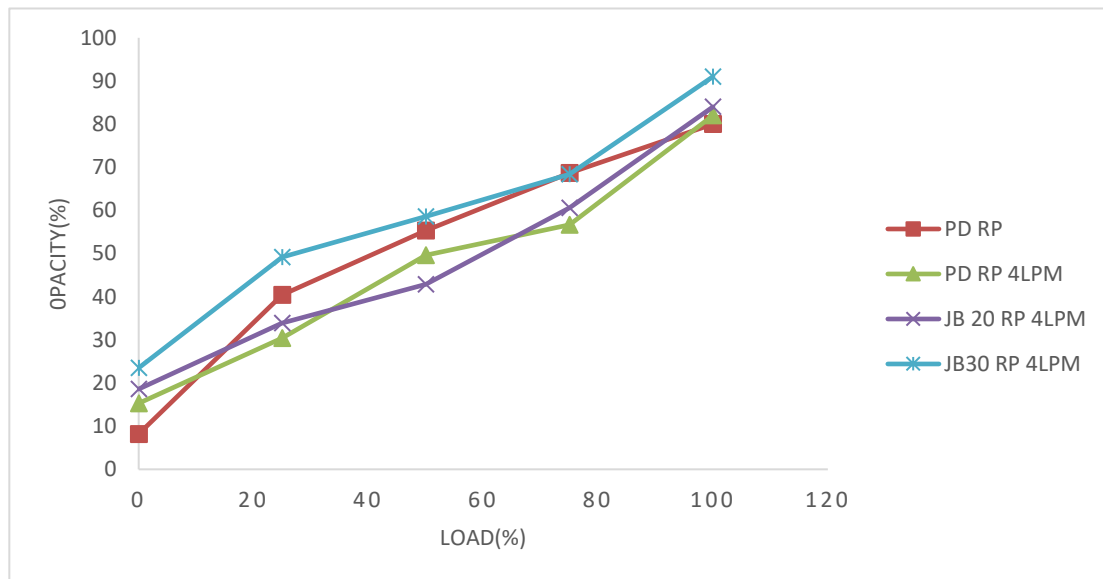


Fig 5.5 Comparative analysis Soot emissions with load

5.6 Engine performance analysis

5.6.1 Brake specific fuel consumption:

The proportion of mass fuel flow rate to engine power is known as BSFC. The efficiency of a BSFC is determined by the characteristics of the gasoline. It is a calculation of engine efficiency in terms of fuel consumption. Figure shows a graph depicting the variance of BSFC under various load conditions. The BSFC values obtained for pure diesel and other pure biodiesel blends appear to be similar to one another, according to reports. However, adding hydrogen to the gasoline reduces the BSFC prices for both pure diesel and biodiesel blends for all loads. Similar findings have been reported in the literature. This loss is far greater for larger loads than it is for smaller ones. In our research, we noted that JB20 with 4lpm hydrogen emits substantially lower BSFC values than pure biodiesel, as seen in Fig 5.6.

In general, adding hydrogen lowers BSFC since the hydrogen flame speed increases mixture forming dramatically. This immediately raises the temperature and pressure in the cylinder, lowering the BSFC.

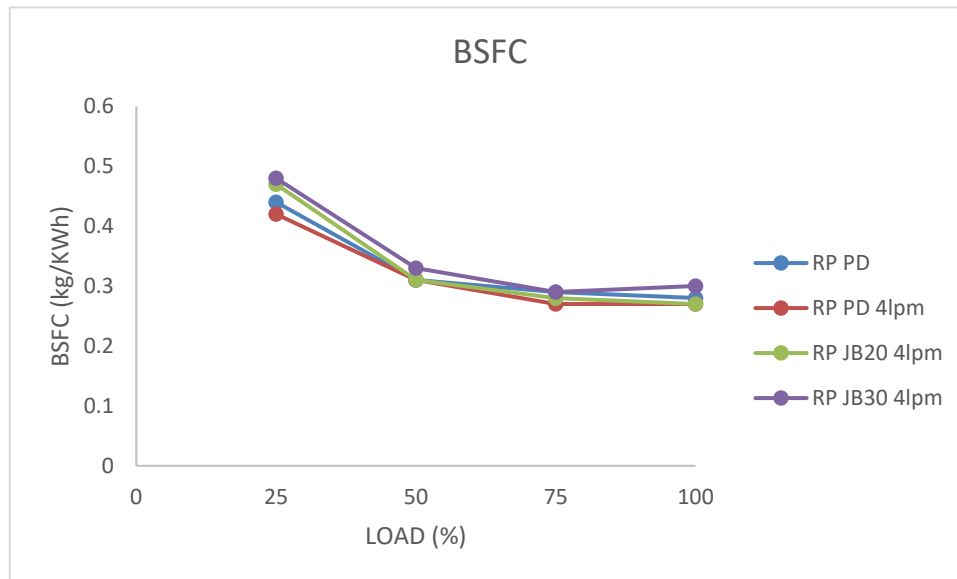


Fig 5.6. Comparative analysis of BSFC with load

5.6.2 Brake thermal efficiency

The overall amount of work that can be derived from used fuel is determined by the BTE. The BTE values obtained from engine testing are displayed in Fig.5.6.2 In a review of the literature, it was discovered that when biodiesel blends were used instead of straight fuel, the BTE of the engine decreased. This decrease is due to biodiesel's high viscosity and density. In addition, poor atomization and a longer ignition interval lead to incomplete fuel combustion. In contrast to pure diesel, BTE increased in fuels with biodiesel blends in our research. In a review of the literature, it was discovered that both hydrogen-added tests and non-added hydrogen tests yielded more or less comparable results.

The largest volume of BTE was observed in our sample for JB20 enriched with hydrogen at 4lpm. Following further study of the results, it was discovered that increased flame strength, high diffusivity, and lower quenching distance led to full combustion.

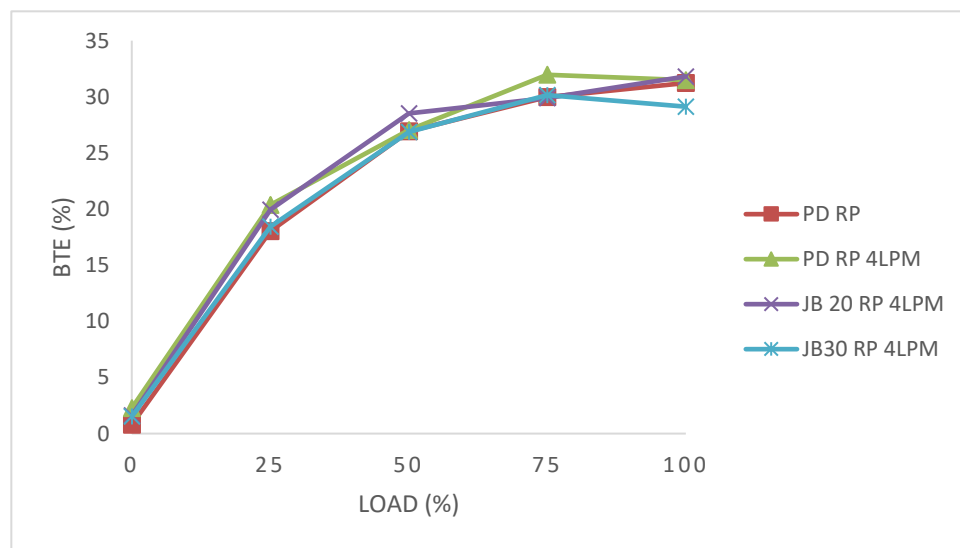


Fig 5.7 Comparative analysis Brake thermal efficiency with load

5.6.3 Heat release rate

Diffusion combustion, premixed combustion, and after burn combustion are the three phases of the combustion process. The heat release rate of a DI engine is determined by the total of these stages. HRR values of a prototype engine with various fuel models are seen in Fig 5.6.3 In a review of the literature, it was observed that the HRR for biodiesel blends was lower than diesel in all of the published values and graphs. As compared to pure ethanol, this reduction is due to the lower calorific value and faster ignition delay of biodiesel blends. However, when JB20 with 4lpm hydrogen was used, HRR was found to be higher than pure diesel and pure diesel with 4lpm hydrogen. Higher flame velocity and instantaneous hydrogen combustion are responsible for this change and rise in HRR values.

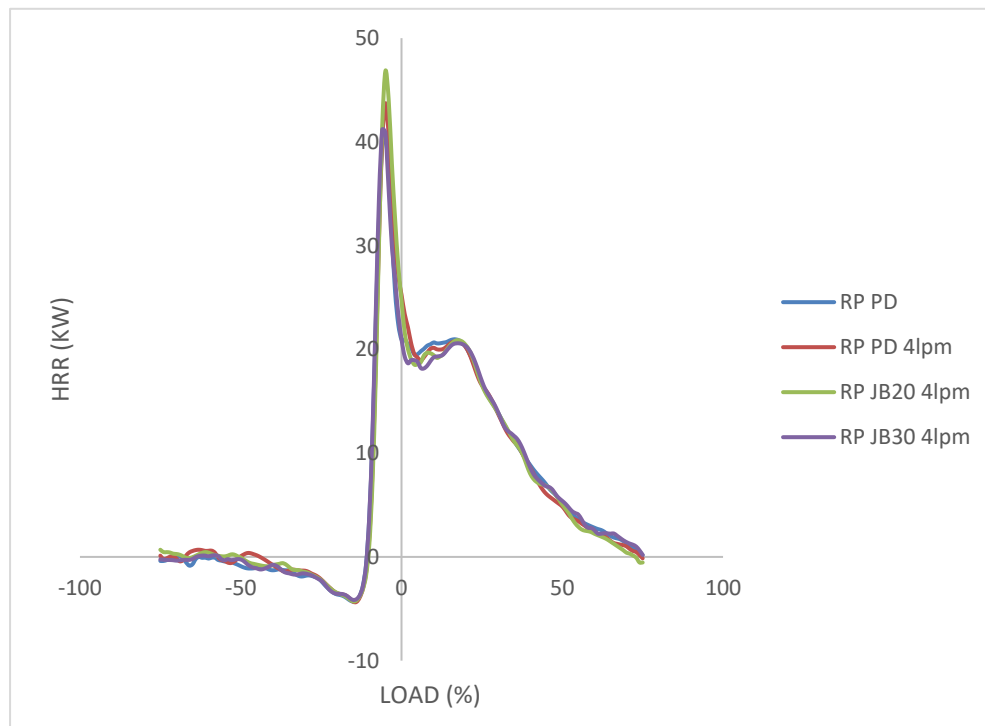


Fig.5.8: Comparative analysis Heat release rate with crank angle

5.6.4 Cylinder pressure

CP is one of the most critical parameters in combustion process analysis. The CP curves depict the distribution of in-cylinder mechanical loads that arise as a result of crank angle combustion. Variations of engine pressure for various fuels are shown below. Fig 5.6.4 shows that the CP curve profiles for all fuel tests are almost identical. However, because of the higher flame velocity, it continues to increase for BV30 with 4lpm Hydrogen. There were no irregular combustion features, such as high pressure rise speeds. In pilot testing, it was discovered that in experiments using pure diesel fuel, peak values were lower than in tests using pure JB20 with hydrogen. When biodiesel is used, cylinder pressures are found to be mild. Another factor contributing to the rise is biodiesel's lower heating value as compared to diesel. The use of JB20 biodiesel with 4lpm Hydrogen raised cylinder pressure in our sample.

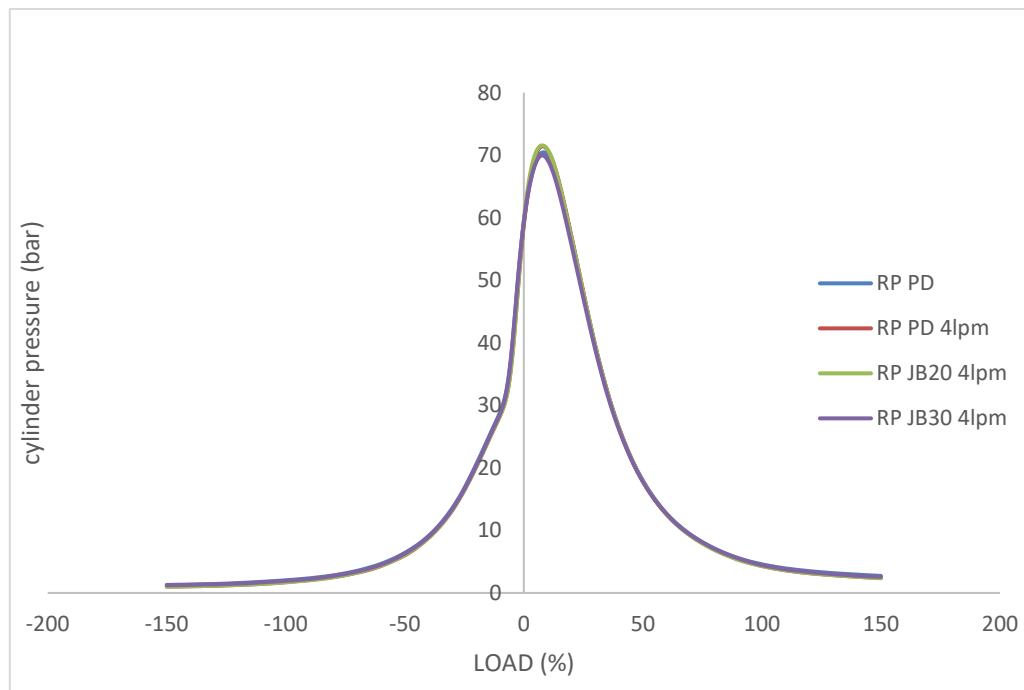


Fig 5.9 Comparative analysis Cylinder pressure with crank angle

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 Summary

The world is currently facing crises of environmental degradation and fossil fuel depletion. The indiscriminate utilization of fossil fuels and extraction have led to minimization of petroleum reserves as well as increase in emissions. The use of bio-diesel will lead to the reduced power loss since the heat generated by them is less compare to the conventional diesel. The global production of poultry broilers is predicted to grow considerably in the future. Intensive poultry farming as well as an increase in broiler flesh waste poses significant challenges to traditional waste disposal methods that is direct land application leading to environmental impacts.

This work is one such attempt at finding an alternate for diesel. Blend of Poultry litter oil were prepared and analyzed using a Direct Ignition diesel engine. The results were further analyzed.

6.2 Conclusion

The study of performance, efficiency, and emission for re-entered piston using biodiesel blend along with a injection of 4lpm hydrogen were seen as follows.

- It was seen during the course of study that NO_x increase for biodiesel blends like JB20 when compared to pure diesel across the spectrum
- soot emission or smoke emission we observed that the emission emitted by Pure diesel, JB20 with 4lpm hydrogen and JB30 with 4lpm hydrogen produced slightly increase of emission in each load.
- The BSFC values is similar for pure diesel blends, according to the report. In our research we noted JB 20 with 4lpm hydrogen emits substantially lower BSFC values the pure diesel
- Also observed in the study CO_2 , CO, HC emission for JB20, JB30 biodiesel blends with 4lpm hydrogen were lower compared to pure diesel.

- It observed that the BTE of IC engine decreased. In contrast to pure diesel in our research. The largest volume of BTE was observed in our sample for JB20 enrich with hydrogen at 4lpm

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ABSTRACT The quest for alternative energy sources is both urgent and appropriate. Finding sustainable solutions that increase performance while reducing emissions not only decreases dependency on fossil fuel but also increases optimal air quality by reducing harmful emissions.

The emphasis is shifting away from fossil fuels due to global carbon emissions and resource depletion. This has resulted in a frantic scramble for alternative energy sources, spanning from wind and solar to biofuel and beyond. Our analysis, which looks at potential biodiesel substitutes, is influenced by this need for alternate energy sources.

The aim is to look into the power, durability, combustion, and nature of emissions of a dual fuel engine that uses WVO biodiesel as the primary fuel. As a secondary fuel, hydrogen was injected into the air intake.

The biodiesel blends used in this analysis are Jatropha oil blended with diesel in volume fractions of 20% and 30%, respectively, to produce BV20 and BV30 fuels. At a rate of 4 lpm, hydrogen and air were pumped together. The acquired WVO was converted into useful biodiesel that was used to create the biodiesel blends using the

transesterification process. This biodiesel blend's performance and emission results in Re-entrant combustion chamber.

INTRODUCTION Energy demand has increased tremendously in the past and will increase even more in the coming years in our world. The non-renewable energy of fossil fuels is being reduced at a rapid rate and this fact intensifies the need to look for alternative fuels to meet our energy needs. The energy consumption rate has increased tremendously.

Conventional energy resources such as diesel, petroleum, gas and coal will soon be depleted; So there is an urgent need to create alternative sources of fuel. Biodiesel is one of the best alternative and renewable fuels. Biodiesel is renewable, sustainable, and possesses similar properties to those of petroleum diesel. In spite of its favorable attributes, biodiesel owing to its oxygen content, leads to higher NO_x emissions proportional to its inclusion rate in fuel blends. And ways to increase the combustion in the cylinder are being investigated. So by changing the piston geometry there can be a possibility of increasing the combustion rate in the cylinder.

Due to the gradual depletion of world petroleum formation on the injectors, carbon deposits, oil ring reserves and the impact of environmental pollution of sticking and gelling of lubricating oil as a result of increasing exhaust emissions, there is an urgent need for contamination by the vegetable oils. There are different suitable alternative fuels for use in diesel engines. In view of methods for reducing viscosity of vegetable oils such as of this, vegetable oil is a promising alternative because it preheating, blending transesterification has well as thermophysical friendly and produced easily in rural areas, where there are properties near to diesel fuel. As the edible oil prices are an acute need for modern forms of energy. Escalating day by day so that researchers are working on the authors mentioned that the use of non-edible non-edible oils. In this study, the experimental tests are vegetable oils compared to edible oils is very significant conducted on a single cylinder diesel engine using because of the tremendous demand for edible oils as food

transesterified Jatropha oil and diesel blended fuel. The and they are far too expensive to be used as fuel at performance parameters like thermal efficiency, specific present.

Rapid increase in the prices of petroleum fuel consumption, volumetric efficiency, brake power and products and harmful exhaust emissions from engines exhaust emission concentrations are determined jointly created renewed interest among researchers to find experimentally. It is concluded that Jatropha oil could be the suitable alternative fuels. It is concluded that the used as an alternative fuel in the blending form. use of any vegetable oil posses some problems when subjected to prolonged usage in Internal Combustion Experimental Set up and Test Rig: In this study, Engines.

These problems are attributed to high viscosity, transesterification of the oil was carried out in the low volatility and polyunsaturated character of neat laboratory using standard procedure. The properties of vegetable oils. High viscosity of vegetable oil causes prepared diesel-biodiesel blends (D100, B20, B60 and some problems in atomization by injector systems and B100) were tested in the laboratory using standard test. 1.1 Diesel engine Every internal-combustion engine in which air is compressed to a high enough temperature to ignite diesel fuel pumped into the cylinder, causing combustion and expansion to actuate a piston.

It turns the chemical energy in the fuel into mechanical energy that can be used to power freight vehicles, large tractors, locomotives, and ships. A small number of trucks, as well as some electric motor sets, are diesel-powered. 1.2 Diesel combustion The diesel engine is a piston-cylinder unit with intermittent combustion. It has a two-stroke or four-stroke cycle (see diagram); but, unlike a gasoline engine with spark ignition, the diesel engine only injects air into the combustion chamber on the intake stroke.

Compression ratios in diesel engines are usually in the range of 14:1 to 22:1. Engines with bores (cylinder diameters) smaller than 600 mm will have both two-stroke and four- stroke designs (24 inches). Two-stroke cycles are nearly

commonly used in engines with bores larger than 600 mm. / Fig 1.2 Diesel combustion The diesel engine produces power by burning fuel pumped or sprayed into the cylinder's compressed, hot air charge.