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REVIEW AND ANALYSIS ON EMISSIONS OF C. I. ENGINE USING PONGAMIA BASED BIO DIESEL

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ABSTRACT

India uses 3.5% of the world's total diesel power, it placed sixth position all over the world. Diesel consumption in India is expected to rise from its current 88.8 bln l in 2025 to 130 bln l, an annual growth rate of 5.6%. Diesel accounts for approximately 70% of total petrol production consumption in India. The anticipated domestic production of crude oil and natural gas in 2006-07 is 33.97 mt. Increased fuel consumption or increased biodiesel production through improved biodiesel fields will be necessary to close the gap between fuel demand and supply while maintaining global food security. To combat the waste of renewable fuels and the resulting pollution, biodiesel was developed. Biofuel is any fuel that derives from plant or animal sources and contains high concentrations of mono-alkyl esters derived from fatty acids. Biofuels can be used in combination with diesel at up to 20% (B20) with minimal engine modification, if any at all. When biofuels are utilised, there is a 30% reduction in emissions of non-combustible hydrocarbons, a 20% reduction in emissions of carbon monoxide, and a 25% reduction in emissions of compounds. Performance, emissions, and combustion parameters of biodiesel derived from non-PMEdible Pongamia oil have been assessed to those of diesel fuel in a standard diesel engine. In this investigation, Pongamia biodiesel with 20%, 35%, and 50% compositions compared to mineral Diesel were tested for their performance. Smoke opacity, carbon monoxide emissions, carbon dioxide emissions, HC emissions, NOx emissions, and NOx emissions were also assessed for each of the test fuels. Crank angle and peak cylinder pressure were used to analyse the combustion process. Experiments indicate that Pongamia non-edible oil and diesel mixes may soon play an important part in the future of diesel engines. This is especially true for small and medium energy products.

1. INTRODUCTION

Renewable fuel biodiesel is made from oils and fats from plants and animals and may be used in any diesel vehicle. Blends of biodiesel and diesel fuel are commonly referred to as "B-2," "B-5," and "B-20," where "B" indicates 2% biodiesel, "B" implies 5% biodiesel, and "B" indicates 20% biodiesel, while "D" indicates 98% diesel. Diesel engines don't need to be modified to run biodiesel blends of 20% or less. Biodiesel in its purest form (B-100) can also be used, however it may necessitate engine modifications to prevent damage and poor performance. With dwindling oil supplies and rising prices, biodiesel is becoming an increasingly attractive alternative fuel. Many scientists have tested the efficacy of biodiesel fuels in diesel engines and its impact on emissions.

It's a clean and sustainable form of energy production. "Bio-based diesel," or "biodiesel," is a renewable diesel fuel made from monoalkyl esters of long-chain fatty acids. Incomplete combustion, carbon buildup, injector choking, and piston ring sliding result from vegetable oil's low calorific value and high viscosity, which makes it difficult to atomize the fuel and form a spray. Transesterification of non-edible vegetable oils results in a cleaner-burning, less viscous fuel. Biodiesel can be processed from a wide variety of vegetable oils, including sunflower oil, jatropha oil, karanja oil, soy oil, rapeseed oil, mahua oil, palm oil, rubber seed oil, etc. Sunflower oil, soy oil, and palm oil are not suitable for use in the production of biodiesel [1].

Since compression ignition (CI) engines are more efficient and can run on less fuel, they are used in a wide variety of applications across the transportation, power, and industrial spectrums. Reduced hydrocarbon and carbon monoxide emissions compared to conventional petrol engines are a direct outcome of improved fuel combustion efficiency. Carbon monoxide, hydrocarbons, nitrogen oxides, smoke, and soot are the most common byproducts of a CI engine's combustion process. Ozone depletion, climate change, photochemical smog, and acid rain are all made worse by these reasons.

Due to the high particulate matter and nitrogen oxide (NOx) generation, CI engines have stringent emission standards that are challenging to achieve. Particle emissions are high because of dissociation and high temperatures in the combustion chamber, which contribute to diffusion. It is difficult to regulate both PM and NOx emissions in a CI engine without making concessions. In addition to the pollution, the rapid depletion of fossil resources means the globe will soon confront a fuel crisis. Finding a suitable substitute for diesel is essential for meeting future demand.

Nonrenewable fuels derived from crude oil have been widely used by humans ever since the beginning of the industrial revolution. About 90% of the world's crude oil is used for transportation and energy. Because of the proven detrimental effect on the environment from their combustion, many countries have enacted regulations to curb these emissions as a direct result of the rapid rise in population. The rising energy needs of the world may soon exhaust the planet's crude oil supplies. All fuels produced by reacting a long-chain alkyl (methyl, propyl, or ethyl) ester with a vegetable or animal fat are collectively known as "biodiesel" by the general public. Biodiesel is typically made by chemically combining lipids and alcohols. Modifying a diesel engine in this way makes it usable either on its own or in tandem with diesel. Availability, heating value, and other physical qualities are all factors in selecting a biodiesel [2].

2. LITERATURE REVIEW

Biodiesel is the most potential alternative fuel for CI engines since it can be produced and distributed at relatively low cost and is widely available. Biodiesel for use in a compression ignition engine has been studied for its optimal raw materials, production process, and emissions. Nadaf looked on using pongamia biodiesel in a CI engine by analysing its efficiency and pollution levels [3]. Pongamia biodiesel was used as a diesel fuel substitute in these tests at concentrations of 5, 10, and 15%. When comparing BSFC and BTE, it was discovered that the 10% blend was the most effective.

In [4], researchers looked into the production process and efficiency of pongamia biodiesel (PBD) in a direct injection compression ignition (DICI) engine. PBD has a lower BTE than diesel throughout a wide range of BMEPs because of its higher viscosity and lower calorific value. Brake specific nitrogen monoxide (BSNO) emissions are higher from PBD engines due to the higher oxygen content and peak in-cylinder gas temperature. Navada conducted an additive performance and emission evaluation experiment with Mad. longifolia methyl ester. Dimethyl carbonate was added to mixtures of diesel and biodiesel made from Mad. longifolia at concentrations of 5, 10, and 15% [5]. When compared to diesel, the BTE of pure Mad. longifolia biodiesel is significantly lower. The use of additives results in a somewhat higher concentration of biodiesel and BTE from Mad. longifolia.

Experiments on PME blends' combustion, emissions, and performance are detailed in [6]. When compared to diesel, PME's maximum CO and HC emissions are 8.2% and 8.9% lower, respectively. Additionally, it has been shown that NOx emissions have decreased significantly. PME's BSFC went up 4.2% while the BTE was down 2.4%. It was discovered that PME has a shorter ID time than diesel, and that this period gets even shorter if more biodiesel is added.

Diesel engines that run on methyl ester Mangifera indica oil (MEMSO) were tested for efficiency and emissions [7]. The composite emissions of BTE, smoke, and HC were all lower than those of diesel. Despite having a lower calorific value than diesel, MEMSO blends have a better BSFC. Using biodiesel instead of diesel, however, increases NOx emissions.

The [8] analysed the efficiency and emissions of a DI diesel engine running on Mad. longifolia oil ethyl ester (MOEE). Despite having a lower BTE than diesel, the lower calorific value of MOEE was found to increase its specific fuel consumption (SFC). It was also found that under all load situations, MOEE has fewer emissions of smoke, NOx, CO, and HC than diesel.

Mahua Mad. longifolia methyl ester/diesel blends were tested for performance and emissions [9] in multicylinder turbocharged diesel engines. The BTE drops and the BSFC rises as biodiesel's fraction in the fuel mix increases. Blends of Mad. longifolia methyl and biodiesel, which contain oxygen, create fewer greenhouse gases (HC) and carbon monoxide (CO) than diesel, which does not contain oxygen. Adding more biodiesel to the fuel mix increases NOx emissions due to the fuel's greater EGT and higher oxygen content.

In [10]. evaluated the efficiency and emissions of LHR engines powered by biodiesel. Their research shows that using LHR coating in conjunction with either biodiesel or diesel yields significantly superior BTE results.

Using biodiesel in low-speed diesel engines has been proposed due to the fuel's ability to boost both power and torque at those speeds. Pineda-Camacho looked into the effects of Ann. muricata methyl ester (AME) on the performance and emissions of a diesel engine. When compared to the other fuels used in the experiment, B20 was shown to have the lowest BSFC. The LHR engine has a slightly greater BTE for B20 mix than the uncoated diesel engine. Coated engines increase combustion chamber temperatures, resulting in higher NOx emissions than uncoated engines for all test fuels [11].

3. MATERIALS AND METHODS

A. Canola oil:

The Latin root rapum, for turnip, is where we get our modern English word rape. Rape-related vegetables include turnips, rutabagas (swedes), cabbage, Brussels sprouts, and mustard

Rapeseed is a member of the Brassica family of plants. Some of the oldest cultivated plants are oil-rich cultivars of the Brassica family, which date back at least 4,000 years to India and 2,000 years to China and Japan, respectively. 55 Its use with oil lamps in Northern Europe dates back to the 13th century. In 1956–1957, a food product utilising rapid fuel extraction was presented to the market, however it was met with certain unfavourable characteristics. Chlorophyll gave the reconstituted oil a bitter aftertaste and a muddy green hue. Erucic acid is also present in large concentrations [12]. In Western Australia, the average price premium for GM canola above conventional canola is estimated at 7.2 percent. Canola Oil is depicted in Fig. 1.

Figure 1. Canola Oil

B.Pongamia Oil

Millettia pinnata, the tree from which pongamia oil is extracted, is native to the subtropical regions of Asia. You can find the tree known as Millettia pinnata wherever in Asia. It is also known by the names Pongamia pinnata and Pongamia glabra. The oil pressed from Mn. Pinnata seeds is known by a variety of names in the languages spoken in the area, including numerous English words. Its oil is known by a wide variety of names, including honge oil, kanuga oil, karanja oil, and pungai. Pongamia oil is depicted in Figure 2 below.

Figure 2. Pongamia oil

C.Alcohol

In chemistry, an alcohol is defined as a molecule with at least one hydroxyl group (functional OH) bound to a whole carbon atom [13]. Ethyl alcohol (the "alcohol" in question) is the chemical name for the compound that is utilised in alcoholic beverages and as a recreational drug.

D.Sulfuric Acid(H_2SO_4)

It is a mineral acid with the formula H2SO4 that is either sulfuric acid (American spelling / IUPAC) or sulfuric acid (traditional / British spelling). It's a clear, thick liquid that takes on the appearance of water at any concentration.

E.Methanal

Methanal, with the formula CH2O, is a chemical found in nature. This is because the pure component is a gas that emits a foul odour and chemically converts into paraformaldehyde. It is the most elementary aldehyde.

F. Prepration of canola oil

Small quantities of crushed canola seeds dissolved in a hexane solvent or cold paste are heated to extract the oil. After the gums and free fatty acids have been washed away in a rain of water and organic acid, the colour has been filtered out, and the odour has been neutralised with a scented drink.

G.Prepration of Pongamia oil

Pongamia oil comes from the seeds of an Asian tropical tree called Millettia pinnata. Millettia pinnata, more commonly known as Pongamia pinnata, is a tree native to Asia. Several different English words are used to refer to the oil pressed from Mn. Pinnata seeds, however this plant is known by dozens of local names. Its oil goes under many names, including honge oil, kanuga oil, karanja oil, and pungai.

H.Properties of Alcohol

Alcohol has a higher boiling point than alkanes of the same molecular weight. Propane has a lower boiling point of -42 degrees Celsius (-44 degrees Fahrenheit) than ethanol, which has a higher molecular weight (MW) of 44. Ethanol has a boiling point of about 173 degrees Fahrenheit (78 degrees Celsius). The much lower boiling temperatures of ethanol and propane demonstrate the stronger attraction of the former to the latter. The capacity of alcohols to create intermolecular hydrogen bonds is largely responsible for these distinctions. Hydrogen bonds are discussed in Chemical Binding: Intermolecular Strength.

3.1 Production of biodiesel through Transesterificationreaction:

In the presence of an acid, alkali, or lipase catalyst, triglyceride (fat/oil) can be transesterified into biodiesel and glycerol by interacting with an alcohol. However, when a strong acid or base is present, the reaction proceeds much more rapidly. The oil from Pongamia Pinnata was transesterified with methyl alcohol since earlier studies have indicated that transesterification with a strong alkaline catalyst, such as sodium hydroxide or potassium hydroxide, is the quickest and easiest to set up.

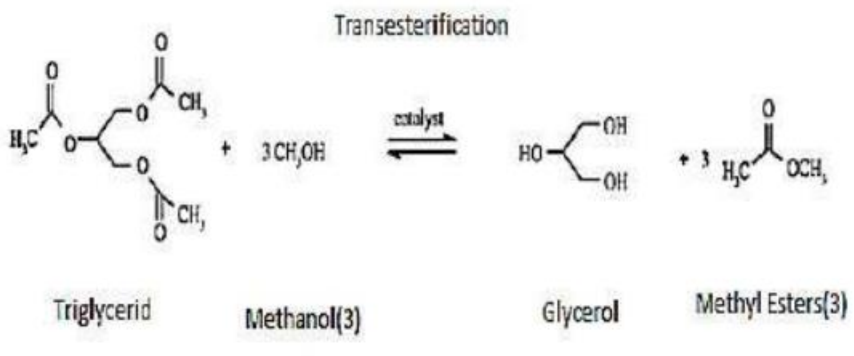

Figure 3: Transesterification Reaction

Triglycerides' high viscosity has led to widespread utilisation of the transesterification reaction. First, methyl alcohol was combined with sodium hydroxide to make sodium methoxide, and then, in a transesterificaction reactor, Pongamia crude oil was heated and stirred to produce biodiesel. The oil and sodium methoxide were mixed together at 60 degrees Celsius and stirred for 1.5 hours to create a reaction. Upon completion of the reaction, the slurry was put into a separating funnel.

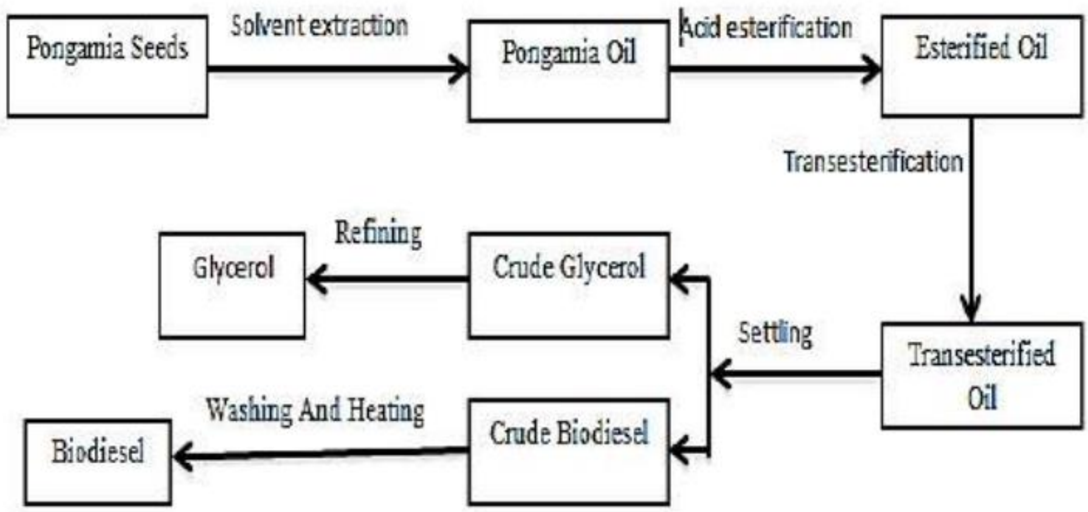

Figure 4: Pongamia seed oil is used to create biodiesel.

Glycerol and methyl ester were mixed together and let to settle for 8 hours. Glycerol and methyl esters were manually separated during an 8-hour settling period. The remaining sodium hydroxide was then rinsed out of the methyl ester in hot water. Chemical tests were performed on the purified biodiesel after it had been distilled to eliminate water [14].

3.2 Oil extraction and biodiesel production

After being rinsed and sun-dried, the parsley seeds were ground to a powder in a blender. Pulverised parsley seeds were placed in an extractor with excess extractant (n-hexane) running for around 5 hours before being dried for 24 hours at room temperature. In comparison to other solvents for oil extraction, the selected extractant is both inexpensive and very effective. It is recommended to employ a two-step transesterification method [15] if your fuel supply contains a high concentration of free fatty acids.

After extraction, parsley oil contains 0.78 percent free fatty acid, making it a candidate for use in the biodiesel manufacturing process by direct alkali catalysis of the transesterification reaction. During the refining process, biodiesel generated from plant oils must lose some of its viscosity, cetane number, and heating characteristics. This usually calls for transesterification to be used. Such qualities are wanted in a bio-based methyl ester vehicle fuel. Because of its high reaction rate and short functional chain, methanol was chosen as the solvent of choice. A bioreactor (product code A-02) with a 50 mL to 100 L volume and an optimal temperature of about 500 °C (made in Mumbai, India by Amar equipment Pvt. Ltd) was used to accomplish the Parsley oil conversion. The catalyst of choice was combined with parsley oil and methanol for an hour at 60 degrees Celsius inside a bioreactor. To expedite the reaction kinetics, these procedures were carried out using a 1% potassium hydroxide catalyst load and a 9:1 excess methanol:oil ratio. Following draining of the bioreactor, the biodiesel and glycerin were separated by density in a separatory funnel. Glycerin was at the bottom of the funnel, while biodiesel was at the top. After the reaction was complete, we rinsed the resulting biodiesel with de-ionized water, patted it dry, and poured it into the sample vial for analysis. The biodiesel production was tested three times with consistent outcomes. Similar investigations in the literature [16] determined the optimal parametric condition for the transesterification reaction, allowing for the production of biodiesel from KOH.

3.3 Engine analysis utilizing parsley biodiesel blends

The engine research made use of a Honda GD411 (made by Honda motor firm in Minato, Tokyo, Japan). It's a diesel engine with a single cylinder, four strokes, air cooling, and direct injection.

In Fig. 5, we see a mockup of the testing vehicle fitted out with all the necessary instruments.

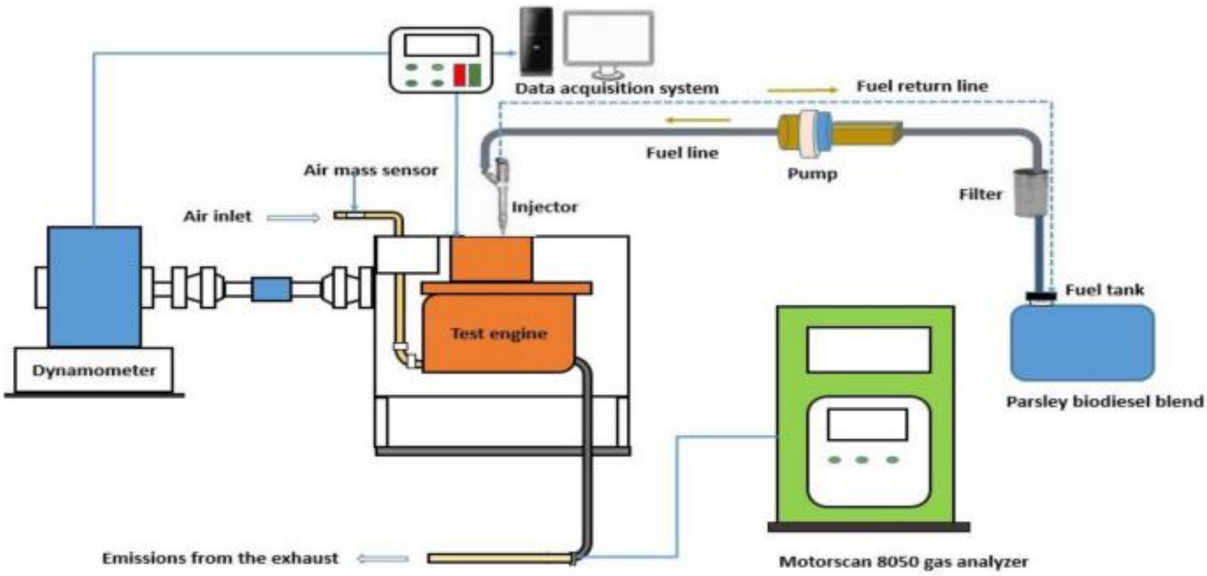

Figure 5: Utilized engine test setup

For 30 minutes at a steady 1500 rpm, [17] describes running an engine on 100% diesel fuel (B0) as the base fuel or reference fuel. The engines were put under stress with the help of dynamometers. A burette and an eddy current dynamometer were used to measure the fuel consumption at varying loads. A complete gas analyzer (Motorscan model 8050) from EOS Motorscan of Parma, Italy, was used to test the exhaust gas for carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx). The engine was set up for the biodiesel blends after the 100% diesel (B0) test was completed. The multiple analyses were recorded as the centrifuge rotated at a steady rate of 1500 rpm to collect the data. An approach was created in collaboration with [18] to put the engine through its paces.

4. RESULTS AND DISCUSSION

Extracted Parsley oil and biodiesel

Oil extracted from powdered Parsley seeds was discovered to have just 0.78 percent free fatty acids (FFA) [19]. Since there is only a 1% concentration of free fatty acids, a pre-transesterification esterification step is unnecessary. After extraction, we only got about a fourth of the crude oil back. Parsley transesterification resulted in a typical biodiesel yield of 96%. The existence of the FAMEs listed in Table 1 was confirmed in the resulting biodiesel via gas chromatography-mass spectrometry (GC-MS).

Table 1 FAME content of parsley biodiesel

Compounds detected	Molecular formula	Composition (%)	#Peaks
Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	12.33	1
11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	15.07	2
cis-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	9.11	3
9,12-octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	27.20	4
10-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	1.23	5
Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	2.14	6

Table 2 Properties of Parsley seed oil, biodiesel blends, and diesel fuel

Fuel properties	PSO	B100	B0	B5	B10	B20
Kinematic viscosity (mm^2/s) (@ 40 °C)	14.9	5.4	3.02	3.09	3.12	3.20
Saponification value	194.81	–	–	–	–	–
High heating value (kJ/kg)	–	39.54	43.90	43.71	42.76	42.47
Refractive index	1.467		–	–	–	–
Specific gravity (@ 40 °C)	0.991	0.899	0.881	0.890	0.897	0.903
Acid value (mg KOH/g)	1.55	0.43	–	–	–	–
Free fatty acid (%)	0.78		–	–	–	–
Cloud point (°C)	2.1	2.3	− 12.2	− 6.5	− 4.3	− 2.5
Molecular weight	882.68		–	–	–	–
Flashpoint (°C)	–	126	68	112	118	124
Iodine value (gI_2/100 g)	103.04		–	–	–	–
Pour point (°C)	− 3	− 2.1	− 17.5	− 8.6	− 7.2	− 5.5
Moisture content (%)	0.55		–	–	–	–
pH	6.8	7.54	–	–	–	–
Cetane number	–	52.1	48.7	49.6	51.2	51.6

The characteristics of the PSO extracted oil are listed in Table 2 [19], and a chromatogram of parsley biodiesel was acquired (Figure 6). The chromatogram shows six peaks, or esters, that can be found in the final biodiesel product. Table 4 displays the typical values for the features of biodiesel fuel (labelled B100), blended fuel sample characteristics (labelled B5-B20), and diesel fuel characteristics (labelled B0).

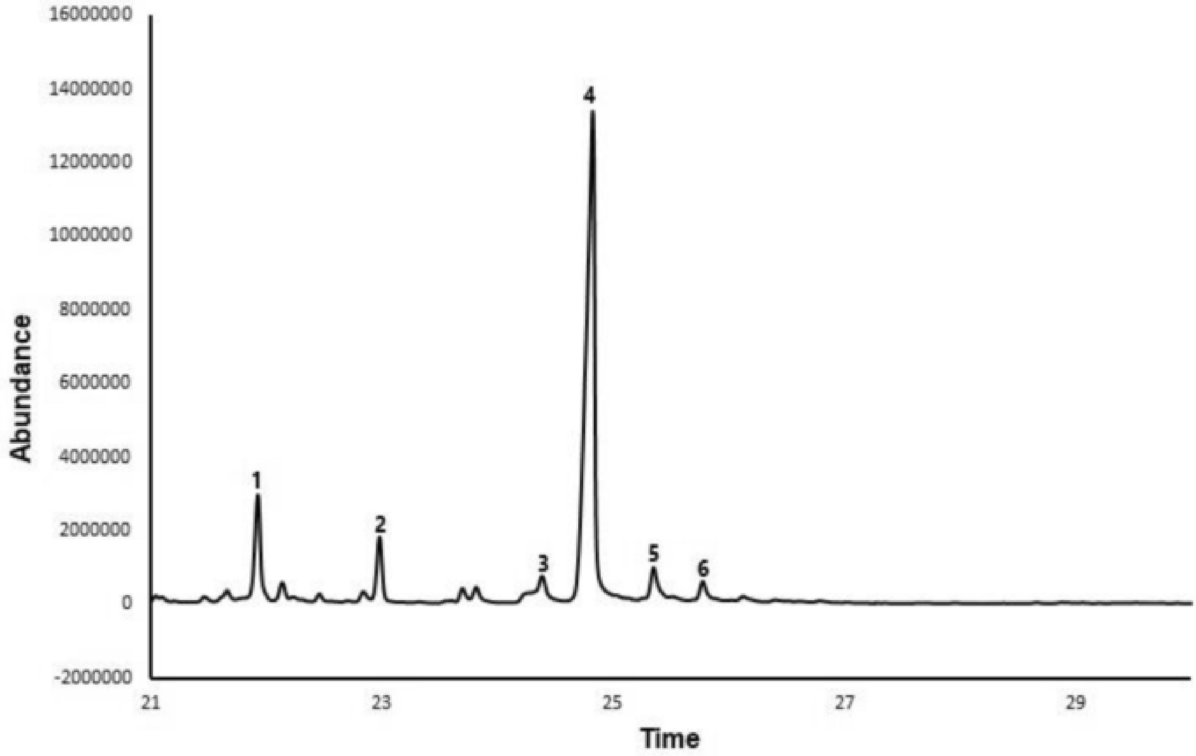

Figure 6: GC–MS chromatogram of biodiesel

Figure 7: Pure Bio Diesel base from Pongamia Oil

A single-cylinder diesel engine at a constant RPM was used for the tests and analysis. We have hooked up a dynamometer to the engine. A voltmeter, an ammeter, and a rpm metre were used to measure the voltage, current, and speed, respectively.The kirloskar oil engines restricted diesel engine from India was chosen for the experiments. There is only one cylinder in the 4.4 horsepower diesel engine, and it spins at a steady 1500 revolutions per minute (rpm). Agriculture, pump sets, farm machinery, and industry are just some of the many places you can find a kirlosker engine in operation.The engine's sturdy build allowed it to withstand the intense pressures it was subjected to during testing. Manufacturer recommendations call for an injection at 27 BTDC. A governor is a device used to regulate fuel flow in response to variations in load, hence maintaining a consistent speed under varied conditions. The engine uses push rods to operate valves located above the cylinders, allowing for open combustion. Cylinder pressure is measured with the use of a piezo electric pressure transducer, which can be attached to the cylinder head.

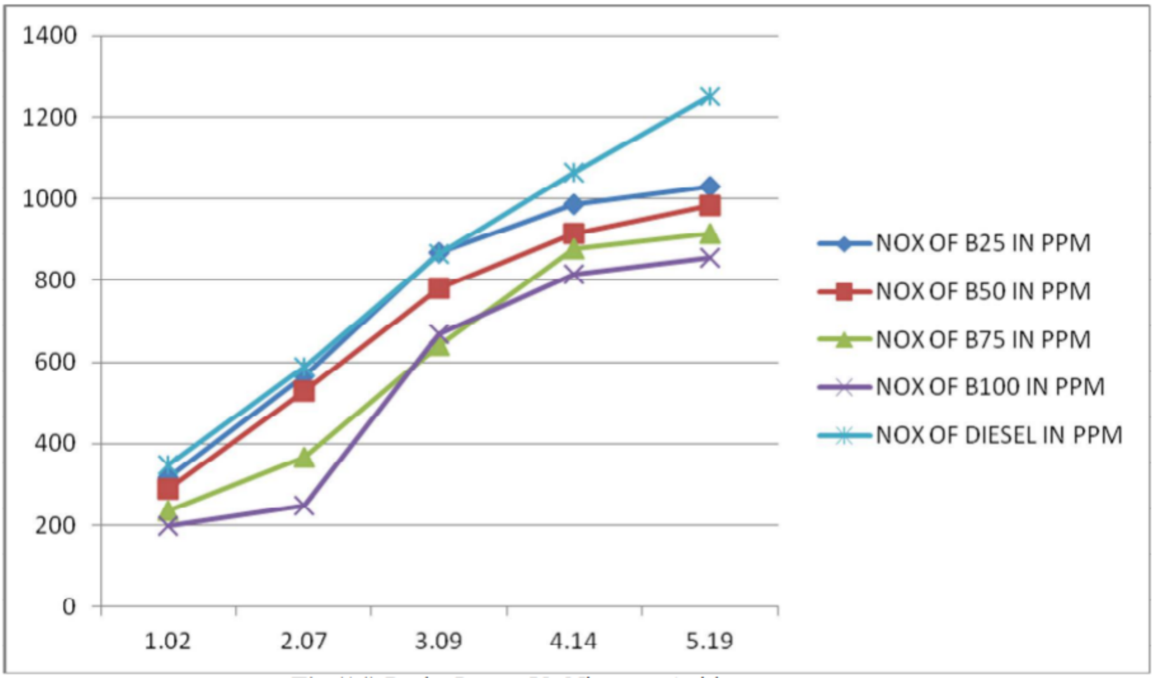

Figure 8: Brake Power Vs Nitrogen Oxide

In Figure 8, we see a comparison of the nitrogen oxide values of four different blends. Blend B100 reportedly outperforms diesel and other mixtures by a wide margin.

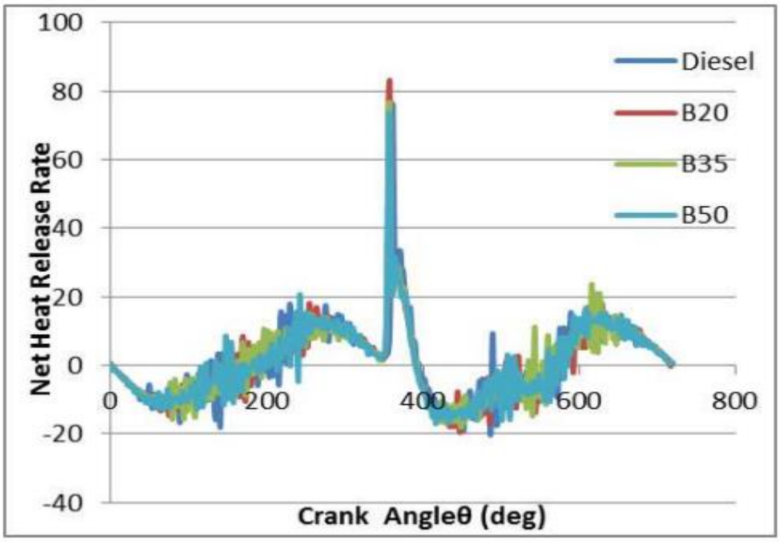

Figure 9: HRR v/s Crank angle

Figure 9 shows the correlation between crank angle and the rate of net heat loss during combustion. At the same cylinder pressure, B20 has a lower value of heat release than B35, with a peak of 82.9W at a crank angle of 357 degrees. Since B50 has a low heat release, the engine needs to be adjusted for it.

The research shows that switching to PME as an alternative fuel or substitute for diesel could significantly cut down on greenhouse gas emissions, while also boosting agricultural employment prospects and discouraging farmers from leaving their rural communities in search of better economic opportunities elsewhere. When comparing PME with diesel, it was found that carbon monoxide emissions were cut by 8.2 percent, hydrocarbon emissions were cut by 8.9 percent, and oxides of nitrogen were cut by a significant amount. The BSFC went up by 4.2%, but the efficiency of the heat transfer went down by 2.4%. However, PME is preferred as an alternative fuel for the transportation, agricultural, and power sectors because of its low environmental impact, high employment for the local community, and encouragement of agriculture [20].

CONCLUSION

Pongamia oil biodiesel's performance and emission characteristics graph proved to be rather instructive. The performance analysis with constant braking power resulted in charts for indicated thermal efficiency, specific fuel consumption, and brake thermal efficiency. The graph clearly shows that the B25 and B50 mixes are substantially closer to diesel than the other blends. The emission characteristics rule out B25 and B50 mixes. We used five gas analyzers to separate out the various components of the emission gas and determine that it was composed of carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO2), oxygen (O2), and nitrogen oxide (NOX). According to the computed graph of emission characteristics, the blend B100 is appropriate for CI engines because it produces less hazardous substances than diesel does. Based on the paper's analysis of the CI engine's performance and emissions, the authors recommend using a fuel mixture of B50 rather than B100 to reduce the engine's exposure to harmful emissions. The results showed that both pure diesel and a mixture including pongamia biodiesel performed better than expected. Blends B20 and B35 had the highest cylinder pressure and heat release rate in response to crank angle. The emission data show that compared to R50, B50 emits significantly less NOx but significantly higher levels of CO, UBHC, and CO2. Since Pongamia biodiesel and its blends have been shown in this study to provide performance and emission outcomes comparable to, if not better than, neat diesel, they can be utilised in place of the latter in diesel engines.

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